UNIVERSITY OF PORT HARCOURT

ENGINEERING TECHNOLOGICAL CHANGES FOR STABLE ECONOMIC GROWTH OF NIGERIA

By

E.K. OBIAKOR
Professor of Mechanical Engineering
University of Port Harcourt

An Inaugural Lecture delivered at the
University of Port Harcourt
On Wednesday, 23 November 1988

INAUGURAL LECTURE SERIES NO. 9.

I am in a very pleasant mood for this opportunity to take the lead in the series of inaugural lectures for the 1988-89 Session.

There might be a kind of curiosity in the minds of some members of this mixed audience about the difference between inaugural lectures and the conventional ones given at Learned Conferences and Seminars. It is conceivable that such members are here now partly because of this curiosity and partly because they have the time to kill.

My propensity, therefore, is first, to dispel their curiosity by describing inaugural lecture as one of the traditional 'rituals' in an academic community, during which a professor, after taking his "chair-of-office", articulates the salient features of the human endeavour to which he has been devoting his career.

He may also highlight the impact which his profession could make on society if his prescriptions for adopting or adapting the salient factors are acceptable. A major distinguishing feature of inaugural lectures is that the professor is allowed freedom to feed his audience with his own chosen menu; and it is not unusual for some members to be nourished while others are constipated by the menu.

In my own case, the 'chair-of-office' has a direct bearing on the engineering-technology profession: the profession that is generally regarded as one of the most powerful vocations influencing the economy of a nation and man's working and living conditions, underlying social changes in a nation and adding new dimensions to the quality of our life on this planet.

Before we run away with the impression that the influence of 'engineering-technology' is entirely beneficial to mankind, let me add, quickly, that it is equally capable of generating complete destruction of a whole community, subjecting many families to profound distress or causing lethal pollution of the environment. In this regard, the experiences of Hiroshima and Nagazaki in 1945 are good examples of what engineering-technology is capable of perpetrating. On the whole, however, its influence has been more beneficial to mankind and the general agreement is that it is an important profession, worth pursuing as a career.

I was elevated to the rank of engineering professor more than a decade ago, on first October 1976 to be exact. Up to that point in time, there was considerable down-turn in the nation's agricultural activities, due to unattractive government incentives and the low income arising from the use of traditional and obsolete

methods of cultivation. In particular, food production was plagued with more than thirty per-cent loss annually; on account of spoilage, damage and improper methods of processing and preservation.

The low productivity in agriculture was so appalling that I decided to relate my inaugural lecture, when called upon to do so to the problems of the agricultural sector. The title of the lecture might have been something like this: *Application of the "Hot-and-Cold" of Mechanical Engineering to the Nigerian Agrarianism*. Although the "hot-and-cold" part of this title may sound like a kind of academic rascality to some people, it is in fact, my mnemonic expression for Thermodynamics & Heat Transfer (the Hot) and Air-conditioning & Refrigeration (the Cold). I would have, then, proceeded to give an in depth account of how these two aspects of engineering could be adapted, in conjunction with mechanization, to transform the quantum and quality of food production in Nigeria.

Unfortunately, the lecture was not given in 1976 or thereafter because, before it was my turn to do so, the Federal Military Government had given me the challenging task of establishing a brand new Polytechnic at Akure in Ondo State. Twelve years have since past and this time around, the title which was considered in 1976 has become stale because Nigeria has witnessed and is still facing economic vicissitudes that are much more serious than the low productivity in agriculture that interested me in the 1970's.

Mr. Chairman, ladies and gentlemen, it may be obvious from the above introduction that my natural compunction is to relate my inaugural lecture to the contemporary economic situation in the country. Consequently, the title chosen for this lecture is *Engineering Technological Changes for Stable Economic Growth in Nigeria.* A number of considerations led to the choice. First, Nigeria has abundant manpower which is estimated to be more than a hundred million people, including very significant numbers of engineering technologists, scientists and other professionals who are capable of contributing impressively to the economic development of the nation. They merely need a sense of direction and concrete encouragement.

In addition, the great 'Architect-of-the-Universe' has deliberately endowed Nigeria with abundant minerals and other natural resources which were, and still are the envy of many advanced countries. The water-resources, vegetation and climatic conditions are such that virtually any kind of food-crops, fruits and vegetables, can be cultivated here by the application of available, scientific and technological knowledge.

Thus, it would seem incontrovertible that the conditions and wherewithal for engineering a truly affluent society exist in Nigeria. Indeed, during the periods of the first and second republics, Nigeria was regarded as one of the richest "third world" countries, generating huge revenue annually from crude oil alone; the so-called periods of "oil boom" or "petro-naira boom".

In those years and for un-natural reasons, Nigerians developed insatiable tastes for foreign goods. Massive importations of these goods and anything that depicted ostentation and conspicuous consumption became the order of the day. The elite class even imported their tooth- picks from Ontario, Canada, and the beach-sands for the filtration of their swimming-pool water, from Europe. The federal and state governments set the pace in the importation 'spree' or 'petro-naira madness'. Indeed, a Nigerian head-of-state was quoted, in the 1970's, as saying that "Nigeria's problem was not money, but how to spend it".

Today, a vast majority of people in the same country is wallowing in severe economic hardships, unemployment, starvation and other excruciating traumatic conditions of the human heart and soul. Equally, many industries are performing below capacity owing to inadequate availability of raw materials while others have ground to a complete halt because of the absence of raw materials or faulty production – machines, with no spare-parts for their maintenance. It is the irony of the whole economic situation irony of a people starving in the midst of plenty that prompted the choice of the subject matter for this lecture. I have confidence that technological changes, carefully and properly engineered, would correct the situation and steer this country on the right course for a healthy and stable economic growth. In this lecture, possible options for the technological changes will be discussed.

A well-known adage has it that "the recognition of our short-coming is the very first step towards self improvement or progress". Consequently, it is considered necessary, before outlining my prescriptions for appropriate technological changes, to draw your attention, very briefly, to the following short-comings that had hampered the economic development of Nigeria since independence; short comings to be eliminated in order to pave the way for technological changes:

1. NEGLECTED OPPORTUNITY

Since independence, our governments, political leaders and the leaders of the private & public sectors of the economy, have all been in complete agreement with the universal truism that technology holds the key to the industrialization of any

nation. But they seem not to be in any agreement as to what technology is, or the directions to follow in our attempts to establish/create a technological environment in the country.

At one point in time, the watch-word was "technology transfer", by which we were to purchase/acquire the necessary technology from the advanced countries. At other times, the leaders advocated that technology should be "copied" or "stolen" (the so-called 'copy-cat'), just like Japan did. The contemporary minority view is that Nigeria should develop its own brand of indigenous or local technology.

Most of us saw how the challenging necessities of the Nigerian civil war created opportunities for our 'technocrats', on the side of Biafra, to demonstrate in concrete terms their talents and potentials creating fascinating and imaginative technological innovations. For example, they succeeded to debunk the myth about crude-oil refining. With only the available "ordinary" materials they fabricated and installed quasi-refineries in, at least, sixteen locations in the area under their control. Throughout the war-period, Biafra did not import a single litre of petrol, kerosene and diesel; their vehicles were propelled entirely with the fuels from the local refineries.

Biafra was not in any financial and political positions to import anything. It had to rely wholly and entirely on the efforts of her engineering technologists and scientists. When salt became an acute problem in the homes, the technocrats quickly set up make-shift processing plants which mass-produced 'white' salt from natural deposits of brine. The same ingenuity was applied to the production of other scarce commodities.

For the war itself, many very effective locally made weapons were manufactured and some of them were christianed, "shore-battery", "Ogbunigwe", and "Corporal-Nwafor", to name but a few. The organization was called 'Research and Production" (RAP), and the group activities covered such areas as chemistry, micro-biology, fuels, weaponry, electronics, machine-shop work and foods, etc. the engineering technologists were responsible for practical fabrication, installation or commissioning of any useful inventive ideas from the above groups.

Mr. Chairman, Ladies and Gentlemen, if our technocrats could achieve all these feats under hostile war conditions when they were also panic- stricken by the cannon-fires of war planes, then you can imagine what they can achieve in peace time. The peace time eventually came on 12th January, 1970, almost two decades ago. What have our successive governments and leaders done to encourage the continuity and possible expansion of the local/indigenous technology which our

technocrats started during the civil war? Virtually nothing; the unique opportunity has been almost completely neglected, save for the setting up of "PRODA" in Enugu with very insignificant funding. PRODA is producing striking results today, thanks to the dedication of its technical manpower.

Instead of doing something to foster large scale indigenous technology, the governments went ahead to establish Assembly Plants and a number of prestigious capital-intensive projects, in partnership with foreign and multinational companies. The alarming feature of all these plants and projects was that they were designed to use imported raw materials and spare-parts, in spite of the fact that identical local raw materials or substitutes existed in the country.

The erroneous belief was that the Nigerian technicians who were to understudy their expatriate counterparts would eventually take over from the expatriates, the manufacture and mass production of the products, including the spare parts and the required plants maintenance.

We have had many years of this brand of 'technology transfer'. But our technicians still appear to be quite incapable of manufacturing quality goods, in spite of the tutelage by their expatriate counterparts. Today, we possess many vehicles, aeroplanes, radio and television sets, electrical and electronic gadgets of all sorts, but no maintenance technology and spare parts. Consequently, you stand the risk of locking yourself inside a Peugeot car which is assembled in Nigeria and labelled ostensibly, "made for Nigerian roads".

Apparently, these cars are not for the roads of other countries perhaps in order to avoid exposing the imperfect workmanship of our plant technicians. Equally, our aeroplanes, flying outside the country, run the risk of being impounded because we lack the maintenance technology to service them here and have to reply on foreign maintenance 'hangers' for which the Airways Authority cannot pay the bills. Obviously, if the above mentioned experience is what is referred to as 'technology transfer', then it is quite inappropriate for this country.

2. ARROGANCE AND FALSE SENSE OF ACHIEVEMENT

There were times when the pronouncements from the so-called 'official quarters', aided and abetted with glaring sensational reporting by the news media, were capable of winning, for Nigeria, very few friends and little influence over other African states. Some of such pronouncements described Nigeria as "the giant of Africa" or "the richest country in Africa" or "the most populous nation in black

Africa". Granting that Nigeria has a large population and potential wealth in natural resources, should these warrant this kind of arrogant advertisement?

In actual fact, the level of industrial development in Nigeria in 1960, the year of independence, was almost exactly at par with such "third world" countries as Taiwan, South Korea, Singapore and Indonesia. Today, Nigeria imports massively from these countries, especially Taiwan whose products, machinery, electronic gadgets and, in particular, motor spare parts have kept our vehicles screeching along, rather than lie completely idle.

In spite of our extensive investments since independence, in the industrial sector and agriculture, the contributions of manufactured goods to the "GDP" (gross domestic product) in Nigeria is extremely low: less than ten per cent (10%). In other countries likes Zimbabwe, Kenya and Ivory Coast, the average GDP is about thirteen –and –a-half percent (13.5%). Thus, it would seem that those who were for the arrogant public statements about Nigeria did not base their sentiments on reality. They overlooked the fact that what mattered was the efficient utilization and management of the natural resources and manpower and not mere possession of them.

The news media are equally guilty of misinforming the general public about the technological achievements in the country. They often accord undue publicity to the most ridiculous and embarrassing claims by a few Nigerians. You must have read about a Nigerian in Imo State who manufactured a Radio-receiver from local "herbs", or the Agricultural Engineer in Bornu (or Bauchi) State who had reached "an advanced stage" in his attempt to build a helicopter with the engine of a tractor or landrover-vehicle. There are many more claims like these, even by Secondary School boys.

In the case of the "herbaceous" Radio-Receiver, the news media failed to reveal the component parts which the 'inventor' produced. We all know that a radio receiver has a variety of components. Such as a loud-speaker, transistors, resistors, capacitors, electrical wires, control knobs and switches, etc. There are specialized techniques for manufacturing each one of these components, and usually, they are produced by different industries with the relevant equipment and technical know-how. But our inventor manufactured with herbs.

For the agricultural engineer's claim, one can only observe that he did not appear to have acquired even the most basic knowledge of, not to speak of professional training in aerodynamics and the design of aircraft engines. If he had such knowledge, he would not have expended his energy on the futile project. As a

matter of fact, even in the advanced countries, the design and manufacture of aircraft engines are so specialized, requiring stringent safety measures, that only a handful of industries, like "Rolls Royce" Company in Britain or Douglas Co. in the USA, engage in them. The other industries, that build aeroplanes, buy their engines from these specialist firms.

There are times also when sensational journalism is lavished, by the news media, on our newly completed project or the proposed ones. The impression is created to the world outside that engineering technology in Nigeria has reached a level that matched those of advanced nations. For example, when the expressway linking Lagos and Ibadan was commissioned, it was described as being of "equal standard" to its counterparts anywhere in the western world". Yet, a few months later, some portions of the road become death traps to motorists.

The Murtala Mohammed Airport at Ikeja, when completed, was reported to be of "international quality by any standard in the world". Today, the electronic "Notice Board" which displays the details of 'arrivals' and 'departures' at the airport is embarrassingly dormant. Travelers now rely on glorified 'Town criers' with microphones, for information. Such boastful phrases as "a thing of the past" makes Nigeria self-sufficient" and "the people will soon smile", have been frequently used by our mass media to describe the impact of the output capacity or potential of any proposed projects. Most of such projects did not in the end get beyond the 'drawing-board' stage.

It is extremely difficult for me and my supporters to understand why our former leaders and governments always gave the impression that Nigeria was on the same pedestal as the industrialized and advance countries, whenever there was a fairly significant addition to our developmental achievements. Our news media, in turn, would accord prominence to the most ridiculous claims of 'break-through' without first ascertaining the technical feasibility of such claims.

Part of the reason, in my view, is their ignorance of the fact that the world is technologically stratified into two major groups, namely, the industrially advanced nations and the industrially developing countries. Nigeria belongs to the second group, and no amount of boasting will promote her to the first group. Some of the nations in the first group have developed to what is termed, "the High Technology" level, whilst most of the 'third world 'countries in the second group are still regarded as industrially underdeveloped. Thus, there are various levels from 'underdeveloped' to "high technology", and the gap between Nigeria's level and

those of the advanced nations is enormous. We cannot bridge the gap by arrogant and faulty advertisements of ourselves and our achievements.

In spite of our wealth in natural resources and raw manpower, we cannot ever hope to reduce the gap unless we revolutionize our strategy for the exploitation of these resources.

It is perhaps the unconscious recognition of the need to revolutionize our strategy that prompted some people to suggest *Technology transfer* and *copying* or *stealing* technology, from the advanced countries, as the only way to our rapid industrialization. They frequently reminded us that Japan was able, through copying, to elevate itself from being a developing economy to the level where it now leads the advanced world in High Technology development. But they overlooked the very simple fact that, to copy well you need to have competent and well-trained hands to carry out the transformation. Japan did not overlook this simple fact and we shall soon listen to the underlying background to Japan's 'success story'.

Mr. Chairman, ladies and gentlemen, I have, so far, gone into much labour to deliver the above critical examination of the Ad-Hoc policies of our government, since independence, and the gross immodesty of our mass media. These policies have generated a kind of mass complacency over the issue of industrialization in Nigeria. If we genuinely aspire for a solid, stable, economic growth in this country, then my critical examination has focused on the need to purge ourselves of our arrogance and the false sense of technological achievements. We must face the reality.

Perhaps, we should also take a cue from the modesty of such countries like India which is a fellow third-world country. But India has been progressing quietly and steadily towards the level of the industrialized/advanced nations, depending almost entirely on the ingenuity and innovations of her technical manpower and financial resources, without much publicity.

It is the technological reality (in all its ramifications) of our economic plight that I propose to discuss from now on. I recall the statement by Professor Mansfield of the University of Pennsylvania (in one of his books) that, "economists, as well as other social scientists, physical scientists, government officials, businessmen, labour leaders and others, have shown a very great interest in Technological Change,…due largely to the growing awareness that our Rate of Economic Growth depends heavily on our Rate of Technological Change".

Since there is this kind of general agreement among enlightened people, it is my view that we in this country should be interested in any strategy which is capable of facilitating rapid technological changes in Nigeria. However, before anything else, we should define Technological Change and then consider what is required to bring it about.

TECHNOLOGICAL CHANGE

Mansfield has also defined technological change as, "the advance in knowledge, relative to the industrial arts, which permits, and is often embodied in, new methods of production, new designs for existing products, and entirely new products and services". In other words, technological change gives rise to the following: new methods of production, new designs for existing products, and entirely new products and services.

Take the aspect of "new designs for existing products" as an example: a motor car is an existing product which was first brought to the world, perhaps, by Henry Ford of the USA. He named it "Ford" Saloon Car. Today, many countries are producing new designs of the motor car and calling them different names. Britain produces 'Jaguar' and 'Austin' cars: Germany's Mercedes and Volkswagen cars are on our roads; Japan's Toyota and Mazda series of cars exist, and we are crazy about the French Peugeot cars. None of these countries is accused of copying from the others. Yet when Japan extended this aspect of technological change to other existing products and made rapid economic progress, Japan was accused of copying, by those who were envious of her dramatic growth.

Technological change is not the same thing as scientific advance, because it often takes place as a result of inventions and innovations that do not depend on new scientific principles. For instance, until the mid-nineteenth century when research methods were first used systematically to develop new products in the field of Chemistry, scientific principles were not put too much practical use.

The inventions that ushered in the industrial revolution were made by practical men who relied mainly on their talents for meticulous observation, trial-and-error, rule-of-thumb, their manual skills and their 'native' intelligence. Even today, many changes in technology do not require new scientific principles. It is equally

important to emphasize that technological change is not the same thing as a change techniques. A technique is the method currently being used for production. But a change is technique is a re-organization of the equipment layout, an alteration of the character of the equipment themselves and, often, an alteration of the quality of the products.

Since Nigeria claims that she has the natural resources and manpower, why has she not followed the example of Japan, Germany, Britain and others to re-design the motor car and produce her own model; or is it that Nigeria does not need the motor car? We know that she needs it just as much as she needs the other existing products which are necessary for our well-being: such products as agricultural machinery and implements, water pumps, labour-saving domestic appliances, electric fans and air conditioners, power supply equipment and equipment for communication, to name but a few.

These products exist and we can afford to buy each one or a few as sample. Then, the definition of technological change allows us to re-design them and produce our own versions, "just like Japan did", without being accused of "copying". Why has Nigeria not done so, in spite of the fact that there are reasonably large numbers of well trained and experienced engineers, scientists and other technical and professional manpower? The main reason is that we have not got adequate numbers of the crucial cadre of technical manpower required for the physical transformation of the designs, by the engineers, to products. Those we have are not recognized, motivated or encouraged by adequate remuneration for the vital roles they play.

Professor Orangun, in his inaugural lecture, explained that engineering is a combination of theory and practice. He also defined engineering as "the art, based primarily upon training in mathematics and physical sciences, of utilizing economically the forces and materials of nature for the benefit of man"". Thus, when we speak of technological change as" the advance in knowledge, relative to the industrial arts…." We can replace, "the industrial arts" by the phrase, "industrial engineering" or "engineering activities".

To execute an engineering project successfully, from the drawing board to the real thing, whether it is the manufacture of products or the building of a hydro-electric dam, we require about four 'cadres' of engineering technologists, namely: the professional/graduate engineer, the technologists (e.g. Laboratory technologist), the technician and the craftsman/artisan.

The professional/graduate engineer is qualified by training and experience to carry out mathematical and scientific evaluations of engineering materials subjected to a system of applied loads or forces, he can design things and supervise their construction, he can research and develop new materials and/or research to update the knowledge for the improvement of his functions and technological changes. His education is *normally* at the university and he has, at least, a degree. He can also manage an engineering enterprise.

The technologist is trained to a lower level than the engineer. He can perform most of the functions of an engineer except 'design' and 'analysis' where his knowledge of mathematics and scientific principles is limited. He can supervise the work of technicians and artisans and his education is normally at the Polytechnic/College of Technology. He possesses the Higher National Diploma (HND). The technician is trained to specialize in a particular engineering field. But he has a general background training in science, mathematics and other relevant engineering courses like engineering drawing.

He can perform as a draughtsman, machinist, engine/machine operator, instrument technician, fitter/maintenance technician etc. He is expected to apply the well-established techniques in solving engineering problems at his level.

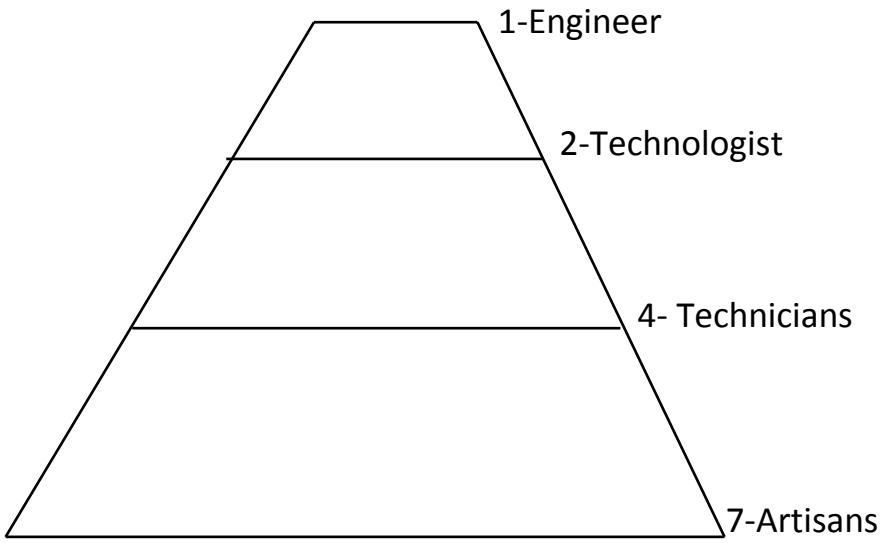
His training is normally at the Polytechnic/College of Technology and he possesses the ND/OND (National Diploma or Ordinary National Diploma). The artisan/craftsman is the person skilled in a particular trade/craft, such as carpentry & joinery, auto-mechanic work, bricklaying, welding & fabrication, electrical wiring, plumbing, etc.

His skill involves a lot of manual work and it is acquired over a period of apprenticeship and tutelage by a 'master craftsman'. Although he may be very good at performing with his hands, he has little or no mathematical and scientific knowledge relating to the job at hand. He may or may not possess a 'trade-test' certificate; but if his training is at a technical college/trade centre, he could be given the college certificate.

The above categories of the technical manpower required for effective applications of engineering technology should remove the confusion in people's minds as to who is an engineer and what are his functions. It is also necessary to emphasize that, although the engineer had previously performed some practical exercises on the same jobs as an artisan and a technician, during his statutory training, he is not as competent as these people in those jobs. Equally, the technologist must first

qualify as a technician, with ND or OND, before upgrading to the HND cadre. Therefore, he is expected to be more practical oriented than a graduate engineer.

Where there are no competent artisans and technicians available, the designs by engineers would be extremely difficult to make or transform to reality. Such is the crucial role the technicians and artisans play in the production, manufacture or construction of engineering products. Thus successful execution of engineering projects demands the full co-operation and team-work of these four cadres of technical manpower. Ideally, for a stable technological development of a country, there must be, at least seven artisans, four technicians and two technologists, for every available professional/graduate engineer. This requirement may be represented diagrammatically by 'frustum of a cone', standing on its broad base.



The base represents seven artisans, and the top-end represents the one engineer. The level of the four technicians is a little higher than the base, while the level of the two technologists is below that of the engineer but above the technician-level (see sketch).

In economic development discussions, the two cadres of artisan and technician are generally referred to as the 'lower-level' technical manpower. The technologist level (HND) is the 'middle-level' technical manpower, while the professional/graduate engineer level is the 'top-level' technical manpower. The stable industrialization and technological development of any nation depends, to a great extent, upon the availability of these three cadres of technical manpower: they must be available in the right proportions (i.e.: 7:4:2:1) mentioned above.

Indeed, the Nigerian "second national development plan" (for the plan period of 1970 to 75) was greatly handicapped and could not be implemented because of the inadequate availability of the lower-and middle-levels of technical manpower. To

remedy the situation, the federal and state governments had to embark upon the establishment of many colleges of technology and polytechnics to produce them. Unfortunately, those who have been produced are not given attractive incentives, motivation and remunerations that matched the crucial roles they have to play. Even the engineers themselves are not accorded the pride of place they deserve in the society, as is done in other countries. Take Japan as a typical example.

EXAMPLE OF JAPAN.

Japan is the pace-setter in the industrial world today and other countries, including the USA, are striving to match her achievements. Yet, about a century and half ago, Japan was a developing country. The information office of the Japanese embassy in Nigeria (Lagos) has confirmed that Japan began the 6-3-3-4 system of education more than one hundred years ago. Ours is yet to take off. They discovered that the educational system boosted the ego of her citizens and the practical skills which were taught at the junior secondary level encouraged the youths to venture into technology. Japan had to plan her technological goals in terms of her needs and the methods for her technological take-off.

A recent report by two technical representatives of Britain's Engineering Council, who carried out a three-month investigation in Japan, has this to say about Japan's technological achievements.

"Japan has a highly educated population at all levels, from 18-years onward and engineering attracts the most able of the 18+ school leavers. The key factor is the emphasis in Japan on Mathematics and Science for the greater part of the whole population and the fact that Japan has created a reward-system which encourages diligence at all educational levels. Moreover, their system ensures that the most able and most highly motivated students enter the university engineering school.

In our own case in Nigeria, the 'most able and most highly motivated student", as evidenced from JAMB and WASC results, are frequently excluded from the admissions into university engineering faculties or polytechnics, because of the so-called "quota system" to cater for the "educationally disadvantaged areas" whose mediocre students are preferred. The British report went further to compare the statistics of engineering outputs in Japan and the United Kingdom (U.K.) and has this to say, "The output ratios for engineering graduates are considerably higher in Japan than Britain. For example, for electrical and mechanical engineering in 1983, the ratio was 3 to 1; for chemical engineering it was 5 to 1 for production engineering 9 to 1.

The Japanese educational system appears to have been designed to make engineering the most attractive of all professions. Consequently, the pool of Japanese school leavers with acceptable mathematics qualifications is ten times higher than that in the U.K. The ratio of applications for engineering places in Japan's universities is 4.7 to 1 compared with 1.7 to 1 in the U.K. In Japan, the essential prerequisite to gaining the most senior management positions in major manufacturing companies is to have been educated as an engineer".

Ladies and gentlemen, the rapid industrialization and economic growth of Japan, from the 1960's, has been based on the above deliberate policy on engineering education and the pride of place accorded to engineers and the other cadres of technical manpower. When our leaders talk about following the example of Japan, it is quite obvious that they are not aware of the inputs that Japan makes to achieve her technological pre-eminence.

Having heard about Japan, a high technological nation, it may be relevant also to consider Brazil, a third-world country which has been striving to elevate her to the level of an industrialized country. Nigeria has been importing goods and machinery from Brazil.

EXAMPLE OF BRAZIL.

It is rather interesting to note that Brazil was, up to the period of the Second World War, in a similar economic situation as Nigeria of today. Up to that time Brazil, like Nigeria, imported almost all the machinery, raw materials and spare parts she needed to develop her economy. But the effects of the second world war compelled Brazil's suppliers to ignore the export trade to Brazil, and instead to concentrate on the re-building and re-establishing their own war-damage economy, utilizing the American "Marshall Plan".

Consequently upon the sudden stoppage of exports into Brazil, the country's industries became starved of raw materials and spare parts. Most of them had to retrench their staff and there was unprecedented unemployment and abject poverty. What did Brazil do to stem the situation? The "information office' of the Brazilian Embassy in Lagos has stated that the country had to look inward for self-reliance. The government embarked upon frequent campaigns to create awareness for local technology and the need to buy 'made-in-Brazil's products.

Brazil used the challenges created by the economic plight to develop her own brand of indigenous technology. A fifty-year plan of technological development was evolved to produce vehicles, spare parts, capital-and-utility goods.

Commencing with the machinery and products which were already imported into the country, Brazil's technocrats formulated and articulated their own style of designs of the available machinery. In 1947, an iron and steel plant was established in Brazil and by 1956, the country was on its way to her industrial revolution: The first made-in-Brazil car, called the "FNM", came into existence in the early 1960s and it was followed by commercial vans, etc. production of other utility goods was carried-on by various industries, using locally sourced raw materials and a minimum of imported materials. Today, Brazil produces about 14-million locally manufactured telephone-sets for her population of about 140 million people (i.e. one set per ten people).

The Brazilian government discovered that it was for the common good of the country for about two-per-cent of her annual budget to be spent on applied scientific and technological research. This policy has paid off because, during the recent world crisis in oil and fuels, Brazil's technocrats produced alcohol from sugar cane. This alcohol has been shown to be a potential fuel for petrol cars. In fact, it is claimed that today, about fifteen thousand of such cars in Brazil are driven with alcohol fuel instead of petrol. Moreover, the researchers have extended their efforts to palm-oil which they hope to convert to a kind of fuel for diesel vehicles.

Mr. Chairman, ladies and gentlemen, with these two examples of Japan and Brazil, I have confidence that Nigeria can achieve similar technological feats, even with her limited (though reasonable) number of engineering technologists, scientists and other professional manpower. My confidence is based on the fact that I have seen a *handful* of our technocrats perform technological wonders during the Nigerian civil war, under very adverse conditions. I was a part of that handful. Today, Nigeria has more than a handful of well trained and experienced technocrats.

The strategy Nigeria needs to achieve a stable economic growth is *Technological Revolution*. Most of my colleagues at the Port Harcourt Branch of the Nigerian Society of Engineers (NSE) agreed with my idea of technological revolution. Indeed, the current national president of the NSE, (Engr. Ife Akintunde) had this to say, about the subject, in his 'goodwill' message to the Nigerian Universities Engineering Students Association:

> "*Nigeria is overdue for a technological revolution.*
> *In the first Place it will start with reorientation in the*
> *basic thinking of all Nigerians. Nigerians will begin*
> *to talk technology, think technology, dream technology live*
> *technology".*

"Technology will manifest at home, at work, on the farm, on the road, and at school. Technology will become the national banner, leading the way and all other ideologies will fade into the background. The technology 'bug' will bite all Nigerians…..and will infest everybody with the disease called 'technologists'. The early symptoms of "technologists" will be a drastic change in the pattern of individual and government spending. Expenditure on science and technology-related matters will shoot-up astronomically, dwarfing other government activities like development of culture, youth, sports, etc. Research and Development will become a beautiful bride, courted and appeased by all industries. It will be a national philosophy, passionately believed in and ruthlessly exploited. 'self-reliance' will cease to be a slogan chanted daily by all official megaphones."

Ladies and gentlemen, this is how strongly the national president of the NSE feels about technological revolution. But unfortunately, he did not elaborate on how the revolution should be pursued. This is where I come in again. I propose that we start with what is available, in term of raw materials, facilities, technocrats and other manpower. Then the modalities for implementing the strategy should be through the following engineering endeavours:

- *Affordable Technology Culture.*
- *Informal Technology*
- *Applied Research*
- *A reward - System of Education In Science and Engineering.*

An in-depth discussion of these modalities will now follow:

AFFORDABLE TECHNOLOGY CULTURE:

Given the present economic crunch, Nigeria is not in a financial position to invest on or import new machinery and products. But it has available materials (imported and local) and a number of already imported equipment, products and machinery. Our existing technocrats should be mobilized (like Biafra did) to re-design and produce/fabricate smaller versions of these products, for smaller outputs. The main essence here is to produce them cheaply so that many people can afford to buy them. For example, we have technocrats who are capable of designing and fabricating small farm tractors of about 5 to 10 horsepower, some of which could be hand pushed and some by engine power.

The modification of motor-cycle type of engine is not difficult, for use in the design and fabrication of appropriate planting and harvesting implements and accessories, suitable for our crops (e.g. yam, cassava, maize, rice, okro, tomatoes etc). Such gadgets should encourage our peasant farmers to increase their outputs. The design and fabrication of grass-cutting machines, to be powered from the P.T.O. (power-take-off) of tractors or lawn-mowers, should boost agricultural cultivation. Ethiopian technologists have succeeded to redesign their agricultural ploughs so that they are now pulled by one mule instead of the traditional two-mule ploughs. And, small horse-power agricultural tractors exist in Taiwan and China for the cultivation of rice, etc. we have artisans and technicians in this country who can fabricate any designs by our engineers.

In the area of post-harvest processing of food crops, where there are problems of preservation and spoilage due to the perishable nature of most products, our available technologists can design and fabricate such things as Drying Cabinets with heaters and fans, dry-air flow, or refrigerated air flow. Drying ovens for products like pepper, vegetables and grain-seeds, merely require the correct burner designs, for which we have many experienced experts. Locally fabricated silos and warehouses should help to eliminate the storage problems of our farmers. For the final preparations of finished agricultural products we require such small-capacity equipment as grinding, peeling, milling, shelling, grating, frying and dehusking machines. Cassava grating machines already exist but small models which are electrically powered could serve private homes, allowing housewives to process their own garri, and other foodstuffs.

Most of our imported machines and industrial equipment are idle today because of lack of spare parts and raw-materials. But there are existing techniques that could be used to produce any re-design versions of the spare parts and components. For instance, the technique of ‘casting’ and ‘foundry’ operation, is a very versatile one for producing any kind of intricate components; and we have artisans and technicians who are experts in ‘pattern’ making and foundry work. The above instances show that we possess the appropriate technology which we can afford, even in our present economic situation, to use in transforming our economy.

You may not be aware that the difference between modern societies in the industrially advanced nations and the developing countries is the extent of utilization and application of technology and the existence of products of technology. In the advanced society, even the most ordinary human activities are served by simple or complex technology, whereas in developing society like Nigeria, people have continued to keep technology outside the main stream of their

tradition and culture. If you enter the house of a family in an advanced society you are likely to find a very simple machine, cranked by hand, for beating eggs for breakfast (the Egg Beater). A similar home in a developing society may be content to use a wooden or metal spoon for the operation.

Portable mechanical kitchen gadgets like grinders, juice-extractors, shellers and extruders, tomatoes and egg slicers, bread-toasters, salt and pepper applicators, etc. are further examples of the products and the application of technology in advanced society. Housewives in Nigeria still manage with granite-stone or wooden mortars and pestles for grinding, instead of using even the small modern grinding machines. These imported modern gadgets are available in our supermarket-shops, but because of their high costs, it is only the elite-class that purchases them. if we can encourage our technocrats to emulate their foreign counterparts and design such, simpler, labour-saving devices, for use around the homes and outside the homes (e.g. lawn mowers), then the country would save a lot on foreign exchange.

Moreover, if our prices/costs for these products are within the reach of the 'common man' and if the products perform satisfactorily, they would literarily 'sell themselves'. There would be no need to urge people to buy "made-in-Nigeria" goods. We will also be creating "technology culture" or technology consciousness among our people.

Ladies and gentlemen, let me repeat that we have, in this country, the artisans/craftsmen and technicians who can re-produce these existing items of imported technology. In addition, we have the engineers who can re-design the products, in a physical size and geometrical form that will enable the artisans and technicians to produce them, easily, using the available facilities in the country. In other words, we have the technical manpower to transform our economy by implementing the modalities we have highlighted under the title, "Affordable Technology Culture".

The handicap, however, is that the relevant technical manpower is scattered all over the nooks and corners of the country: some artisans and technicians may be found in the private industries and public corporations; some may be self-employed or unemployed. Most of the engineers are in private practice or doing other jobs than their trained vocations, others are in the universities, polytechnics, research institutes etc. Consequently, the problem is how to mobilize all of them to practicalize this philosophy of "affordable technology culture."

A solution which I recommend strongly is that the federal government should establish an autonomous body to be known as the "National Engineering

Technology Agency" (NETA) whose status should be similar to N.P.A (Nigeria Ports Authority); NNPC, NRC (Nigeria Railway Corporation), it should have the responsibility of mobilizing the available relevant technical manpower, especially the well-trained and experienced artisans, technicians and general technologists, from where ever they are in the country. It should also responsible for the designs and production of the capital, utility and consumer goods required to make Nigeria self-sufficient (or nearly so), using minimum of imported raw materials.

To perform effectively, NETA should consist of a number of functional divisions each of which shall deal with specific needs. For example, an Agricultural Machinery Division should produce the low and medium horse-power tractors required by private farmers; agricultural implements, tools and garden appliances and grass-cutting machines. A spare parts division should manufacture the various components and parts required by the industries whose machines have been idle due to lack of the spare parts. Other divisions could be for General Merchandise/Goods, Domestic Appliances, and Food Processing Equipment etc.

The NETA headquarters (at Abuja or Lagos) would determine the tasks to be assigned to each division and the target dates to produce results. The divisions themselves would be sited in various locations in the country and their work collated and coordinated by the headquarters. For NETA to succeed, its technical manpower must be adequately motivated and attractively remunerated. Therefore, it must be well-funded by the Federal Government, initially, for a period of consolidation.

Its products and goods could be sold to the federal and state governments, and the general public, through the usual marketing outlets in the country. The work and functions of NETA should be without prejudice to those of Research Institutes, on-going industries and universities, etc. Since, initially, NETA would have no workshops and production facilities of its own, it should arrange to use those available anywhere in the country, such as the Railway workshops at Ebute metta, Enugu and Zaria; the Foundry Industry at Ilupeju and the Machine-tool Company at Oshogbo, to name just a few.

This idea of a national engineering technology agency is not a far cry. It is the natural thing to do in our present economic situation, and it is a kind of the cue we should take from other nations in similar dilemma. For example, the USA established her "National Aeronautical and Space Administration", NASA, in the 1960's when she wanted to compete with Russia in the race to the 'outer space' and to the moon. Britain, too, set up her "United Kingdom Atomic Energy

Authority", UKAEA, when she decided to develop her own independent nuclear arsenal. Thus, our NETA is quite compatible with our aspirations for an indigenous technology for self reliance.

Another modality for our technological revolution is what I call, "informal technology".

INFORMAL TECHNOLOGY

In modern manufacturing industries, the production of sheet-metal goods such as enamel-wares (e.g. plates, cups, cooking pots & sauce pans etc), knives, spoons, forks, buckets, watering-cans, cylindrical containers, etc, require the installation of all kinds of hydraulic and pneumatic press-machines, complemented by other mechanical machines and machine-tools. Various machine operating-techniques are used to produce, for example, a head pan, a shovel-head, a kitchen plate or dish, saucepans, and cylinders etc. But in our society today, there are people with very little formal education and no technical education at all who can fabricate metal trunk boxes, buckets, plates and cups, cooking-pots, water-cans, gallon-measuring containers, etc. without the use of these modern machines. We call them tinkers.

There are others we call blacksmiths, who fabricate machetes, table and kitchen knives, hoes, shovels, garden rakes, door-hinges, bolts and staples etc. These are people endowed with natural creative talents and inventive ingenuity which they demonstrate by producing functional items of utility goods, using techniques that I refer to as "informal technology". In addition, at the road-side-workshops/shades erected by self-employed artisans and technicians, we see a lot of ingenious devices and appliances created by these people to increase their productivity and/or to eliminate the drudgery in the manual skills applied to their jobs.

For example, the tyre-vulcanizer has a lever-press-device for extracting the tube from the tyre, instead of the usual manual method of hitting the tyre-rim with a sledge-hammer. The welder fabricates fascinating designs of iron security-gates', storage bins and wheel barrows with expanded-metal type of cart-frame for carrying goods by the petty traders and hawkers. Auto-mechanics, mechanical fitters, and carpenters, all have their own designs and fabricated labour-saving gadgets that help them to increase their productivity. In particular, our electrical technicians now make use of a very clever device, cranked by hand, to re-wind the burnt coils of electric-motors, alternators and electric generators.

It is rather unfortunate that the enormous contributions, which informal technology makes to our economic well-being, are not given the sincere appreciation and recognition they deserve. Even the state and federal governments frequently treat the 'informal technologists' with disdainful apathy. Quite often, some local governments send out their bulldozers to destroy the road-side workplaces of these artisans and technicians, in the name of environmental sanitation, without providing alternative salutary locations.

An African country like Kenya has since recognized the economic importance of informal technology and the Kenyan government has gone out of its way to provide "soft" loans to their informal technologists. No wonder, therefore, that the Gross Domestic Product (GDP) of Kenya, at 13.5%, is very much higher than that of Nigeria, at less than 10%. Since Nigeria is now committed to look inward for her technological self-reliance, I strongly recommend that our government (Federal and State) must do something concrete to motivate and encourage our informal technologists.

For instance, a special industrial area should be allocated to them and designated "Low Technology Industrial Estate" (Low Tech. I.E). The estate must be provided with the relevant infrastructure like, electricity, water and good access roads. Also, soft financial loans could be granted to deserving technologists. There is no doubt, that this recommendation, if accepted an implemented, is capable of boosting the ego of existing informal technologists and encouraging the hitherto dormant ones. In consequence, there could be a dramatic escalation in the production of "low-tech" utility goods for the home markets and even for export.

We should remember that many communities in Nigeria have their individual reputation for traditional production of certain low technology utitility goods and craft. Examples include the iron works, gun and weaponry works in Akwa (Anambra State) and Nkwerre-Isu (Imo State); the bronze works in Ife, Bida, Minna, Jos Bauchi and Borno States; the Benin and Ikot Ekpene carvings and toys; the decorated calabash, wood and leather goods and toys in kano, kaduna, and Sokoto States; etc. The proposed low technological industrial estates, in each state, could stimulate and enhance a significant development in the production of these products and crafts.

Annual Trade Fairs could be organized in the States to popularize the low technology goods. A side effect of the existence of such industrial estates would be an unconscious development of 'technology culture' among our people.

There might be skepticism in the minds of many people about the quality of the goods and products which would be made by the proposed 'affordable' and 'informal' technologies. In my view, the question of poor quality should not arise if there is adequate "research and development". The problem with most of the "made-in-Nigeria" goods is that no subsequent research is carried out to improve their quality and performance. Whereas, imported goods usually go through a few stages of research and development before they are marketed, our locally made products are rushed to the shops and markets after the first or maiden production, without much quality control. I have the following remarks to make on the kind of research and development that should solve our problem.

APPLIED RESEARCH AND DEVELOPMENT.

There is no doubt that research holds the 'master-key' to the advancement of scientific knowledge. And when coupled with 'development' the knowledge is invariably translated into dramatic technology changes that influence the quality of goods, processes and our life generally.

There are two types of research, namely, *Basic and Applied*. Basic research is the original investigation aimed at discovering how nature operates, in the field-of-interest of the researcher. Normally, basic research leads to advancement in scientific knowledge, though the knowledge may not have any specific or immediate economic objectives. By its nature Basic research is usually expensive and slow to yield results; and the result may be negative and useless.

Applied research, on the other hand, is the investigation directed to the discovery of new knowledge which has economic objectives, relating to products or processes. 'Development', could be defined as the technical activities undertaken to translate research findings into products and processes. Thus, whereas research yields new knowledge, development turns the knowledge into practical use. Development involves design and construction of models or prototypes and even pilots-plants and experimentation.

As a developing third-world country, Nigeria should concentrate all her research efforts on applied research. There is a lot to be done, through applied research, to upgrade and improve the quality and efficiency of the products and goods to be made by the proposed 'affordable technology' and 'informal technology', for our

self-reliance. We cannot afford the luxury of engaging our resources on basic research. The existing research institutes in the country should each be given specific assignments geared to specific needs. They must also be given adequate funds for the work and a specified period within which to produce results. This approach is yielding very impressive results at PRODA (Enugu), F.I.I.R.O; ASUTECH; I.I.T.A. and Umudike's Root Crops and Cereals Research Institute, to name but a few research places in the country.

The discussion would be incomplete without any remarks on the issue of 'education-and-training' of more technocrats who would contribute to increase the rate of development, and quality, of self-reliant technology in Nigeria, as advocated in this lecture. I have in mind, a "reward system" of selective education.

REWARD SYSTEM OF EDUCATION, FOR SCIENCE AND ENGINEERING.

It is well known that the pre-requisite for engineering education is a solid foundation in mathematics and the physical sciences. And since the universities, polytechnics and technical colleges all receive their students from the secondary schools it is absolutely essential that the quality and standard of science and mathematics, taught at the secondary-school level must be adequate enough for the students to cope at the higher institutions.

Already, at this point in time, there is a widely held view that the students entering the institutions of higher learning are poorly equipped in science and mathematics. The secondary schools themselves are reported to lack adequate number of science-teachers, equipment and materials. As a result, the experience of most of our universities is that enrolments for degree in Mathematics and /or Physics are not encouraging enough, especially if we wish to produce graduate teachers of science and mathematics for our secondary schools.

Most of the students applying for admission into the engineering programmes of universities are found to be deficient in mathematics and the physical sciences. Consequently, the enrolment in engineering is very much below what it should be, for a country like Nigeria with her mammoth population and her aspiration for a rapid technological growth. Indeed, the NUC's statistics on the "total enrolment" in all Nigerian Universities, the relevant part of which I have reproduce (see Appendix), show that the total enrolment in the 1965/66 session for engineering and technology was 660 students (all universities), with that in "natural sciences" at 1,320. In the 1970/71 session (after the civil war) it was 1,302(natural science,2,512); in the 1980/81 session it rose to 4,929 (natural science 9,503), but

in the recent 1986/87 it stood at 10, 461 (natural science 17,467); which was a big drop from the previous enrolment (1985/86) due to the effects of 'SAP' and other austerity measures.

When the above figures are converted to percentages of the total students, enrolled in all disciplines, in the corresponding period, we would find that the results depict an appalling situation for engineering and technology. For a country that has been shouting on top of her voice that she places a high premium on science and technological education, industrialization and economic growth, this state of affairs should not be tolerated. What can we do to correct the situation?

Ladies and gentlemen, as a concerned Nigerian and in all sincerity, I humbly recommend the following studied actions to the federal and state governments, actions that are far-reaching, involving some preferential treatments: - First and foremost, science and mathematics should be made compulsory in all our secondary schools. Those schools that are not equipped for science or are inadequately equipped, should be supplied with equipment produced by our indigenous technocrats. In this regard, contracts should be awarded to appropriate engineering faculties of universities and polytechnics for the specific equipment they are capable of fabricating. I am aware of many faculties in these institutions and in the research institutes and private industries that can produce good educational equipment.

As an incentive and motivation to continue with science, all students who attain specified grades of pass in science and maths at the end of the First Year in the secondary schools, should be awarded full scholarship. This scholarship would be renewed yearly providing that the students maintain the given levels of pass. They lose the scholarship for they fail to reach the grades of pass in either science or maths.

The question of inadequate science-teachers could be remedied by engaging the services of the available unemployed graduates of science and engineering and the HND-holders. These people already have enough depth of knowledge of mathematics and science to be able to teach at secondary school level. An attractive "science allowance" should be paid to the teachers, to retain them.

Secondly, science, engineering-and-technology education at the Nigerian university, polytechnic and the technical colleges, should be free to all Nigerians who gain admission into these institutions. The free education should cover tuition, boarding or its equivalent, and a very generous allowance for books, materials and field trips. However, any student who fails to pass the promotion examination to

the following year's class loses the free education. This deliberate preferential treatment for science and technical education is designed to encourage the production of the country's future bread-winners, in matters of technological achievements and economic growth. Japan, Brazil and other countries are doing similar things to motivate their citizens to embark upon careers in technology.

Thirdly, our technocrats must be accorded the pride-of-place they deserve in our society. This may be reflected in the salaries and wages paid to engineers, technologists, technicians and artisans. Above all, our engineers should be consulted, always, for professional advice, relating to any proposed technological projects. This approach will be a practical demonstration of the confidence we repose in our engineers and it should also eliminate the white-elephant projects which some of our political leaders would wish to establish in order to ruin the economy and/or enrich themselves.

As we approach the twenty-first century (which is 12-years from now), having attained 28 years of political independence, nothing would give Nigerians more national pride, self-satisfaction and respect by the world at large, than to see their indigenous technocrats produce the goods and services they consume; the machinery, implements, tools and the various appliances they need to increase their productive capacity, with full employment and no starvation for all by the year 2000.

We have the relevant natural resources, and therefore we should be prepared and willing to make any sacrifice and pay any price to see that we produce and motivate adequate numbers of Nigerians who would accomplish our dream of a better Nigeria for all of us. In this regard, we will have very little to lose, but so much to gain, by accepting as inevitable, the strategy, modalities and the recommendations I have submitted in this lecture.

Mr. Chairman, ladies and Gentlemen, here ends my lecture and thank you for your attention.

APPENDIX

NUC'S STATISTICS ON TOTAL ENROLMENT IN NIGERIAN UNIVERSITIES: 1962/63 TO 1986/87 (FOR ENGINEERING & TECHNOLOGY; AND NATURAL SCIENCE).

Session	Engineering & Technology Total Enrolment	Natural Science Total Enrolment	Remarks
1962-63	312	707	
1963-64	435	936	
1964-65	514	1,078	
1965-66	660	1,320	
1966-67	783	1,632	
1967-68*	479	1,154	War Year
1968-69	609	1,357	War Year
1969-70	675	1,594	War Year
1970-71	1,302	2,512	Peace Returns
1971-72	1,594	2913	
1972-73	2,264*	3,465	Increased No. of Varsities
1973-74	2,,702	4,022	
1974-75	2,852	4,148	
1975-76	3,249	4,852	
1976-77	2,761	5,041	
1977-78	3,169	6,649	
1978-79	3,439	7,633	
1979-80*	3,995*	8,159	Free technical education effect
1980-81	4,929	9,503	''
1981-82	5,026	11,761	''
1982-83	5,911	13,432	''
1983-84*	8,993*	14,862	6-new Unitechs Opened.
1984-85	10,026	16,969	''
1985-86	11,327	18,840	'' & SAP
1986-87	10,461*	17,467	SAP effects

REFERENCES

1. ORANGUN, C.O. (1980): 'Engineering: A Combination of Theory And Practice'; An Inaugural Lecture, University of Lagos, Lagos-Nigeria.

2. MANSFIELD, E. (1968): 'The Economics of Technological Change'; Published by W.W. Norton & Co. Inc, New York.

3. BLEARS, J AND BONWITT, B.J. (1987): 'A Comparison of the Statistics of Engineering Education: Japan and the U.K.'; A Report Published By Engineering Council, No. 10 Mattravers Street, London.

4. AKINTUNDE, I. (1988): 'Goodwill Message' NUESA Magazine, Faculty of Engineering, University of Port Harcourt, Nigeria.

5. ANONYMOUS (1987): "Technological Development in Japan"; Private Communication with the Information Office, Japanese Embassy, Lagos.

6. ANONYMOUS (1987): "Brazil's Technological Development": Private Communication with Information Office, Brazilian Embassy, Lagos, Nigeria.