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The development of human resources: the provision of science education in secondary schools

Operation, efficiency and desirability of special science schools at secondary level: the Nigerian experience

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Provision of science education in secondary schools

One of the major challenges facing human resources planning is dealing with the uneven level of technological development in different countries. The world has witnessed a huge scientific and technological explosion in recent decades; but not all societies have been equally affected by this process. Yet the ability to master and apply science and technology are indispensable to the process of modernization and development of economies.

Well aware of this fact as early as the 1960s, developing countries embarked on programmes to support the development of science education at secondary and higher education levels. Much has been achieved and the number of pupils and students enrolled in science courses has increased almost everywhere. However, expectations have rarely been met and lack of science trained personnel at higher- and middle-levels continues to hamper the socio-economic development of many countries. The reasons for this state of affairs are many: well trained and motivated science teachers have remained in short supply in most countries; curriculum reforms have not been implemented as planned either because the necessary resources have not been available or because it takes time, in any case, for schools and teachers to change their habits and teaching methods. More recently, science education seems to have particularly suffered from the economic austerity which has led to a decrease in real terms of the resources allocated to education in a number of countries. All these problems have been aggravated by lack of co-ordination between the numerous administrations and institutions concerned with secondary education and by insufficient planning. As a result, science education in a large number of countries is still in a critical state.

The overall objective of the IIEP research project on *Planning the provision of science education* is to appraise the state of secondary school science in a range of developing countries and to reinforce national capacities to plan and manage this education in ways which will contribute to human resource development.

Studies and monographs undertaken under this project specifically aim at:

(i) establishing the condition of science education at the secondary level in countries at different levels of economic development;
(ii) developing techniques and indicators of use to the planner in assessing science education provision;
(iii) identifying strategies for providing science education in a more effective way; and
(iv) measuring the impact of science education on human resource development.

The project focuses on general secondary education. There is little point in trying to implement policies aimed at strengthening scientific training in higher education if students at the lower levels are ill-prepared. Another reason for this choice is that development depends not only on a few highly trained science specialists but also on the existence of a well-trained middle-level manpower and on a science literate population. In a context of economic uncertainty and rapid technical change, it is all the more important to improve the quality and flexibility of the workforce and seek more effective methods of training. The better the initial education provision, especially in science, the easier it will be to provide specific training later and to organize re-training. The implementation of an education designed to form inquisitive attitudes in students, encourage understanding and problem solving rather than rote learning -- an education aimed at creating a scientific spirit -- however, raises a series of problems.

One of the most crucial dilemmas that planners from developing countries have to face is whether they should distribute the scarce resources available in science equally across all secondary schools, or whether they should concentrate these resources (the best teachers, laboratories and equipment available) on a few specialized schools in order to better prepare those students who will continue studying science and later pursue science-based careers. Nigeria and within Nigeria, the State of Kano, is one of the places which has decided to create specialized science schools at secondary level. Such a strategy raises a number of questions: How to select pupils who will attend such schools? How early should the selection and specilization take place? What resources should be devoted to these schools? How should these institutions be monitored and administered? Last, but not least, an important question is how effective are these schools in preparing pupils for further science studies and careers? These are some of the questions that Dr. Abdalla Uba Adamu, from Bayero University, Kano, Nigeria, addresses in the present monograph and which are of interest to many planners seeking cost-effective methods of teaching science.

Executive summary

This monograph explores the development and outcomes of special science secondary schools as a strategy for human resource development in Nigeria. The science schools were aimed primarily at enabling specially selected senior secondary school students (Grades 10-12) to be taught science subjects in a new and different environment from that of conventional secondary schools. These schools were seen as the main way Nigeria will eventually have a large supply of highly qualified manpower in science and technology, believed necessary for modern social and economic development.

The monograph focuses on the institutional realities of the science schools and provides an insight into the mechanism of these as agencies of manpower development in science and technology disciplines.

The findings of the analyses demonstrate the powerful stimuli of economic and political forces in the development of science education innovations, especially in Nigeria. At the same time, the study also discovers that there is a need for provisions which protect innovations in science education against political and economic instability which leads to deviations from the primary objectives to the extent of such innovations. This is all the more significant to the extent that developing countries rely on administrative initiative for science educational reform, rather than initiatives from pressure groups both within and outside educational circles.

Despite these possible pitfalls, the outcomes of the Kano State science schools as innovatory strategies in provisions for secondary science education clearly indicates that such strategies are desirable, particularly in the light of the large number of graduates such schools could produce over a period of over ten years. And if a proper institutional framework is provided for their operation, such educational facilities can certainly also help enhance the quality of science-trained human resources and be maximized for ultimate efficiency in the use of science education as an instrument of economic social development in any society.

Contents

Chapter 1

Human resources development and science education in developing countries: a brief over-view

What makes science education so susceptible to review and innovations is the widely held belief that economic prosperity can only come through modernization, which, in turn, comes as a result of reliance on science and technological training. As the Committee on Science and Technology in Developing Countries (COSTED) observed:

> "The development of human resources, as important as the development of natural resources, will require proper realistic education. ... This leads logically to a consideration of the role of science and technology in education. Scientists and technologists are required in the economic infrastructure of an industrial society, no matter how unsophisticated it may be." (Radhakrishna 1980, p.38).

This is all the more so in developing countries where the steps towards a modern culture are being contemplated. A review of the science curriculum or its provisions in a way that places prominence on the interpretation of science in social advancement therefore justifies constant curricular reviews.

Further, students who were introduced to science instruction in the way envisaged by the post-Sputnik science education reform rationales of the early 1960s are expected to constitute a better class of manpower raw material in *science and technology*. Such *manpower* would be in a better position to appreciate, contribute to, and identify with, the modern world of science and technology. Because of this, a prominent feature of some of the new science curricula (i.e. the post-Sputnik version), especially in developing countries, is the reflection of a rationale linked to manpower development objectives.

Thus, there is a high level of commitment, in both developed and developing countries, to the provisions of educational facilities serving as the basis for much more effective training of manpower in science and technology disciplines. This was, for instance, emphasized in the declaration of the UNESCO Conference of Ministers of African Member States Responsible for the Application of Science and Technology to Development in Dakar 1974, where:

> "The Conference... noted.. the continuing weakness of African scientific and technological potential. Since men represent a country's main wealth as well as the agents of its development, the first task must be to develop African universities and apply an education policy aiming at the democratization and reorganization of instruction, including more especially the upgrading of scientific and technical training at all levels." (UNESCO 1974, p.10).

And because science is the focus, the initial attention of the commitment is on the nature of the science curriculum, and in some other cases, the institutional context of teaching science subjects to children at all levels of schooling. The main focus, however, remains the science curriculum, reflected in wide-ranging science curricular reforms that swept to most parts of the world at the beginning of the 1960s.

There were subsequently educational and political expectations that the science programmes produced by the reforms should constitute balanced *science education for all learners*, regardless of ability or the level at which their education will terminate. This strategy is seen as the basic step towards achieving a measure of national economic self-reliance through science and technology. Thus a new theme, particularly in developing countries, enters the science curriculum reform discussion and that is 'science education for relevance and self-reliance' (Bude 1980).

This theme is further reflected in a review of recent development plans from African, Asian and Latin American countries, which as Lewin (1984) analysed, were concerned with social equity and nation-building considerations; at the same time these plans lay a special stress on scientific and technical education because of the assumed links between the educational characteristics of the labour force and productivity, even though such links were often generally stated.

But although the science curriculum has been the first focus of reform in the interpretation of the role of science education in social and economic development, a second strategy (sharing the same emphasis) focused not on the curriculum directly, but on the creation of school environments aimed at achieving the same goals as the curricular reforms.

This second strategy, as part of a long-term planning of *provisions for science education* (especially at the secondary education level), was aimed at the continuous production of school leavers with the pre-requisite inclinations towards science as a subject of study, and consequently as a career. Examples of this category of reform in science education included the Turkish Science Lycee (Maybury 1975), The Fitz-Mat Preparatory Science School in the Soviet Union (Baez 1976), and the MARA Technical institutes and science schools in Malaysia (Malaysia 1976).

In Turkey, for instance, the Ford Foundation in 1964 substantially financed the development and establishment of a Science Lycee, designed to cater for high ability children with aptitude for science education. As the Turkish Minister of Education explained in introducing the Lycee in February 1962:

> "As for our country, I find it suitable to found a High School of Science where students with high ability could be boarded without charge ... and the graduates of such a high school should further their education in the fields where they are most gifted." (in Maybury 1975, p.112).

One of the Malaysian strategies of long-term science education reform also involved the government setting up special science schools. In the Malaysian Government plan the main emphasis was placed on the building up of a significant potential (not only of the elite) of science-trained human resources for the labour market; fully residential science schools should become an important feature of the upper secondary education with restricted but nevertheless substantial enrolment capacities

In Kano State, Nigeria, a science education strategy belonging to this latter category of innovations was introduced by the state government in September 1977: Special science secondary schools were created to offer science education to specially selected senior secondary school students (Grades 10-12) under different conditions from conventional senior secondary schools in the state. The main objective of the science schools was to provide an educational context where Kano State students potentially skilled in, and with high inclination and aptitude for, science and technology disciplines could be developed as a large stock of manpower for the effective social development of Kano State.

What makes learning facilities like the science schools an interesting focus for study is their radical departure from the curriculum development package deal associated with large-scale science education development. Moreover, they offer at least two sociologically pertinent dimensions. First, they reverse the egalitarian notion of education. Instead of making science education a province for each child, they deliberately cater for only a selected few, considered naturally 'gifted' or at least more gifted than others.

Secondly, they provide a facility for the long term production of scientific manpower, using a science curriculum which shares the same broad characteristics as reflected in the 1960s post-Sputnik American science curriculum reform movements. These characteristics include placing emphasis on student's ability to control his or her learning processes in science through guided discovery of scientific laws, theories and facts with emphasis on self-discovery.

The purpose of this monograph is to determine -- with special reference to the Kano experience -- the efficiency of special science schools with regard to achieving the mentioned manpower development objectives; at the same time it will give insight into central issues of implementation and operation as well as some major policy implications.

Chapter 2

The Nigerian experience in science education reform: the emergence of the Kano State science secondary schools

2.1 The Kano State science secondary schools

The Nigerian experience in science education reform, perhaps not surprisingly, followed the pattern set by similar developments in the USA and the United Kingdom in the early 1960s. This was characterized by an initial soul-searching of values and purposes of current practices in the teaching and learning of science subjects from primary to senior high schools.

However, while science education reforms across the world were motivated mainly by a feeling of dissatisfaction with the existing methods and materials of teaching science to children of specified ages, the pattern of development of the Kano State science secondary schools was totally different. This is because the schools evolved not as a direct concern for the *quality* of the science curriculum or its teaching, but as a result of the concern of the Kano State Government about the *quantity* of science based high school students produced in Kano State secondary schools as a whole, and the extent to which these students could contribute to the effective scientific and technological development of Kano State in particular, and Nigeria in general.

Kano State was created out of the then Northern Region of Nigeria in 1968. The emergence of the new state was not without some problems for the state administration because Kano State lacked indigenous (i.e. of Kano State origin) expert scientific and technical manpower considered essential for social development.

This situation arose because modern schooling -- the main agency of manpower training in Kano -- had not yet gained wide acceptance among the populace. It was still viewed with suspicion as a forum for conversion to Christianity (Kano State 1976a, 1983).

This was the situation in Kano when the oil boom era exploded in Nigeria in the early 1970s. As a result, the Kano State Government launched a very ambitious developmental programme in 1971 (Kano State 1971). The strongest feature of this plan was its attention to agriculture and industrial development. These two areas -- agriculture and industry -- received far greater attention from the Kano State Government than others, including education. The task of co-ordinating and seeing to the implementation of the various developmental projects brought about by the 1971 Development Plan in Kano were given to the Ministry of Economic Planning which formed a committee, the Manpower Development Committee, to carry out the co-ordination.

The only major obstacle to these ambitious plans -- or, as the Plan identifies, 'bottlenecks' -- was the lack of expert manpower in science and technological fields. Although the vibrant Nigerian economy meant that the Kano State civil service could afford facilities with the required manpower being recruited from overseas, the government gradually realized that such manpower could not be relied on to remain for long periods.

To confound the situation, local substitutes (i.e. those from Kano State) that could be relied to stay on a permanent basis were not available in the quantity or in the disciplines required. This is reflected in the overall manpower situation in Kano in the period in *Table 1* which reveals a shortage of indigenous manpower in all fields of social and economic development at the creation of Kano State and in the first three years of its existence.

The gravity of the Kano State manpower situation reflected in *Table 1* is emphasized when it is considered the total estimated population of Kano State at the time was over 6 million, indicating, for instance, in the case of doctors, the patient-doctor rate was far from adequate for the population of Kano State. Further, it is significant to note in every manpower discipline, there are more expatriates than Nigerians. And even then, the number of Kano State indigenes was not much more than 'other' Nigerians.

Table 1. Kano State manpower strength in science and technological disciplines, 1968-1970

	1968				1969				1970			
Occupation	K	N	E	T	K	N	E	T	K	N	E	T
Doctors	3	0	22	25	3	0	28	31	5	1	29	35
Pharmacists	5	6	0	11	5	6	0	11	7	8	0	15
Architects	0	1	3	4	0	1	3	4	0	1	8	9
Surveyors	1	0	2	3	0	0	1	1	0	0	3	3
Engineers												
- Civil	1	0	5	6	1	8	0	9	0	2	13	15
- Water	0	0	4	4	0	0	2	2	0	2	10	12
- Electrical/Mechanical	0	0	4	4	0	1	4	5	0	2	5	7
- Irrigation	0	1	0	1	0	1	0	1	0	0	6	6
- Agriculture	0	1	0	1	0	1	0	1	0	1	0	1
Agriculture												
- Veterinary Offs.	0	0	2	2	0	0	3	3	2	1	4	7
- Animal Husbandry	1	0	0	1	3	0	0	3	3	1	0	4
- Agricultural Offs.	1	1	3	5	5	2	2	9	8	2	3	13
- Pest control	0	3	1	4	1	3	1	5	1	3	1	5
Totals	12	12	47	71	18	22	45	85	26	24	82	132

K = Kano Indigenes; N = Other Nigerians; E = Expatriates; T= Total

Source: Kano State 1970. *Kano State Statistical Year Book 1970.* Kano, Military Governor's Office, Economic Planning Division.

This situation was complemented by the general feeling among government officials in Kano that schooling was not functioning in a way which identifies with social and economic development. As stated in a government document:

> "The acute shortage of manpower in Kano State results largely from the lack of the right kind of educational facilities. In more of our secondary schools, the available science teaching facilities, laboratories, equipments, materials compared against actual school requirements are far too inadequate." (Kano State 1979, p.138).

This trend had disturbing effects on the overall economy of the Kano State Government, not only in terms of its contribution towards the implementation of social projects, but also in its effects on the general welfare of the society where highly trained scientific and technical manpower is needed for social advancement. These thoughts were further reflected by the Kano State Government where it observed:

> "Although secondary education in the state has expanded very considerably over the last few years, the number of students graduating in science and technical subjects remains a very small fraction. Our schools and universities are still dominated by the study of liberal arts. In Kano State for example in 1975/76 West African school certificate examinations, only 12 per cent of our candidates took science subjects. In 1977 it was noted that although the first indigene of Kano State in the field of medicine graduated over 20 years ago, yet the state cannot boast of more than 10 medical doctors who are indigenes of Kano State." (Kano State 1979, starts p.43, continues p.139).

It was under these circumstances that the Kano State Government set up a Manpower Development Committee in 1975 to explore specifically the issues of scientific and technological manpower shortages in Kano State. This was made more pressing with the new-found oil-wealth in Nigeria which led to the establishment of more social projects -- roads, agricultural projects, provision of electricity in rural areas, building more hospitals, provision of housing estates, and so on.

It eventually emerged that in every project, there was a conspicuous lack of scientific and technical manpower, especially from Kano State, as reflected in *Table 1*. What emerged was a conviction that something must be done to increase the number of personnel from Kano State with scientific and technological skills to lead these projects. The direct outcome of these sessions was the proposal that a series of special schools, to be known as special schools of science, should be established in Kano with the sole purpose of selecting students with natural gifts in science and providing them with a very rigid science curricular diet. It was envisaged that these students would constitute a very large potential base for further training of manpower in scientific and technological disciplines.

The proposal was sent to the Kano State Ministry of Education in 1976 and was accepted. In 1977, the Kano State Government produced a blueprint on the establishment of the science secondary schools in January through the establishment of the Science Secondary Schools Management Board Edict[1] in January 1977. The Science Secondary Schools Management Board was established in March 1977 by the Kano State Government under the control of an Executive Secretary, and answerable to the Commissioner for Education. The creation of the Science Secondary Schools Management Board was intended to make the science schools as independent as possible from the Kano State Ministry of Education.

What makes the establishment of the Science and Technical Schools Board quite striking is its being the first of its kind in Nigeria, and coming from a state traditionally associated with conservatism in contemporary educational affairs. The proposal to establish the science secondary schools provided three other distinct characteristics for the Schools.

First, the Kano State Ministry of Education provides the schools and students for the science schools. All the science schools have boarding facilities, unlike other schools in Kano which are day schools. This was to provide the students with full opportunities of concentrating on academic work under structured supervision.

1. Edict: This refers to the *Official policy* establishing the Science Secondary Schools Management Board. At the time that the Board was established in 1977, Nigeria was under Military rule, and virtually every policy statement which stands as a blue-print for specific action issued under this system of government is referred to as an *edict* (also *decree*). However, under civilian administration, official policies are referred to as *Laws* which reflected their endorsement by *lawmakers* after a consultative debate.

Second, the science school students were drawn from academically excellent students selected from Form II cohort of all secondary schools in Kano. This was after a selection examination. Finally, all the science schools have eight science laboratories, two each for biology, chemistry and physics, and one each for geography and technical drawing. Subject choices in the schools are quite rigid. All the students must study biology, chemistry, physics, mathematics, English language, geography, and either Hausa language or Islamic studies (these being the only liberal arts subjects offered to them). In addition, the boys have a choice of one elective from technical drawing, agricultural science or further mathematics. Girls do not have these electives, although food and nutrition is a compulsory subject for them, and not offered to the boys.

To complement these facilities was a no-expenses-spared effort by the Science Board to recruit the most highly qualified science teachers for the schools -- offering them totally different, and better, conditions of service to those available in the normal Ministry of Education secondary schools. To complement these service conditions were attempts by the management of the science schools to provide an effective teaching climate in the science schools to make teaching in the schools less frustrating (for instance, by the provision of every item of science-teaching equipment required by the teachers -- made possible since the Science Board had a direct subvention from the Kano State Ministry of Finance, rather than Ministry of Education).

These are all provisions which radically differ from what is found in conventional secondary schools in Kano under the Ministry of Education with most schools having only two laboratories catering for all the main science subjects, including integrated science. As an official of the Science Board summarized:

> "The special features of the science schools in Kano are perhaps heavy investment in terms of equipment and materials and the type of manpower we have as teachers, as well as the human element, i.e. the students themselves who had to be pre-selected through rigorous series of examinations and tests to make sure we are really getting the right kind of student for what we intend to do. And I think

these three things make the science schools much better, or in a class of their own, compared to other secondary schools." (Interview 29 September 1986).

Once the Science Board was established as an administrative organization, its objectives became much more clearly formed. According to an internal communication dated 5 April 1984 which gives the details of the organizational structure of the Science Board, the Board is vested with:

> "the responsibility for providing science education at secondary level, with the following hopes and aspirations in mind:
> - that more secondary school leavers with science background will eventually be produced;
> - that the majority of those so produced will proceed to higher institutions of learning;
> - that in the long run, a crop of high level manpower (doctors and engineers) will be available;
> - that the expected insignificant few that might not necessarily be doctors and engineers might find themselves in the Polytechnics for HND/OND courses in: (i) engineering (civil and mechanical); (ii) agro-allied, food technology, laboratory technology fields, health and nursing care."

2.1.1 Girls and science education in Kano

Perhaps one of the more significant features of the entire science schools project in Kano is the inclusion of girls secondary schools - no doubt the most innovative strategy in Nigerian education, especially in the strongly Islamic communities of Northern Nigeria with traditional hostilities towards the Western form of education. As a Kano State Government Committee (The Galadanchi Committee) set up to analyse the problems of education in mid 1970s in Kano observed:

> "There is still, in our society, the lingering suspicion of western education as an agent of Christianity. As a result of this suspicion, it is difficult to convince a great number of our people of the desirability of sending boys to school, let alone girls." (Kano State 1976a, p.35).

The gravity of the situation as it affects the enrolment of girls into western-type schools in Kano persisted up to the 1980s, when the transition rates of girls from primary to secondary schools in Kano was only 12 per cent in 1981 (Kano State 1983).

It was against this background of female education in Kano that the establishment of girls science secondary schools in 1981 in the state was seen as a very bold move. But perhaps not surprisingly, even with this move to provide more opportunities for girls to study science education within a legislative framework, especially in a traditional society such as Kano, elements of stereotyped stratification from officials about the students' eventual careers was somehow inevitable. For instance, in most official statements, it was made clear that a major objective of the girls' science education in Kano was to produce women doctors and nurses. Not much emphasis was given to the need for the production of women engineers, geologists, aeronautic engineers, computer scientists, veterinary doctors, or agricultural engineers. As an official rationalized:

> "If you go to the hospital today, you will find that up till now the ratio of medical personnel is more men to few women attending to females; you see more men attending to female patients than females attending to female patients. By the establishment of the Girls' Science School, this problem should be reduced." (Interview 29 September 1986).

This expectation, of course, may also be a reflection of Kano State economy and social structure; women doctors may be in higher demand than computer scientists or engineers. However, the expectation that girls should enter into the 'caring professions' is prevalent in many other countries. For instance, Kelly et al (1982, pp.281-295) carried out a survey of gender roles at home and school and found that British parents rate the job of doctors and nurses for girls on a higher mean rating of suitability than for boys.

This expectation -- which excludes girls from 'hard core' sciences - may also be a deliberate government policy to shield female students from the rigours associated with the handling and movement of equipment. This was made explicit by the Kano State Government's refusal in 1990 to allow its female students to study introductory technology in all the State's junior secondary Schools.

This direction is in contrast to the provisions of the national policy on education which stipulate that introductory technology should be compulsory for all students at the junior secondary school level. Instead, the Kano State Ministry of Education insisted on making home economics compulsory for all girls, at the expense of introductory technology (Daily Champion, 2 June 1990).

In any event, with the establishment of the girls science secondary schools, new innovative ground was broken by the Kano State Government. The literature shows this to be a relatively rare event in both developed and developing countries.

The next chapter provides a detailed description of how the broad aims of the establishment of the science secondary schools in Kano were expected to be attained through institutional provisions.

Chapter 3

Implementation and operation of the science secondary schools project in Kano State

This Chapter analyses how the science secondary schools project has been implemented in Kano State. The analysis is based on an inter-related framework consisting of (i) the student selection procedure in the schools; (ii) operation and efficiency in the science schools, and (iii) measures undertaken to enable cost-effective science instruction in the science schools.

Perhaps one point should be made clear concerning the entire conception of the science schools project in Kano, and which affects its implementation. While most curricular-oriented projects were often enshrouded in a specific approach that provides an overall picture of the project from any perspective, this was not the case with the science schools. For instance, the primary emphasis of the project was on the production of a *greater number* of students to study science and technology disciplines, rather than on the *content* of what they learn. This is evidenced by the lack of any set of curricular materials specifically oriented to the science schools learning environment (teacher and students' guide-books, project brief, project evaluation period or stages, trial of the philosophy of the project on a limited basis or even feasibility studies) before the whole project was started. As one of the initiators of the project admitted:

> "Our main interest was to provide a situation where you give yourself the chance to select the best students that are endowed in science and develop that so that they could now perform better than they used to. The idea of being dissatisfied with the teaching of science at that time was not in anybody's mind. Not as a concept. We had no quarrel with

> the equipment as we didn't even know the equipment. We knew there were equipments and there were syllabuses and so on. But we didn't bother ourselves even to look at them because we were not experts. Our expertise is only in provisions." (Interview 7 January 1987).

And from field work data (see Adamu 1988), these provisions were restricted to well-equipped laboratories, teachers with degrees in science disciplines (and not necessarily including teacher training), and a copious supply of standard recommended textbooks for Nigerian science education.

This illustrates the fact that the science schools arose from economic and political considerations, rather than concern for, and ultimately provision of, specified curricular materials.

3.1 Student selection procedure

3.1.1 General over-view

Students selected for admission into the Kano State science secondary schools are drawn from a pool of junior secondary school graduates who must have finished three years of Nigerian junior secondary school education (which emphasize integrated science and introductory technology in its curricula). The science schools therefore operate as senior secondary schools, and the average age of the students in the first year (SS1, or Senior School 1) is 15.

The policy-makers behind the science schools project endorse this arrangement, because as they argued, by the time the students finished the science school, their average age would be about 18. This, the policy-makers further argued, makes the students mature enough to tackle the world of work if unable to continue their schooling, or intellectually adept enough to tackle the next stage of their schooling, which is direct entry into university degree courses.[2]

2. This arrangement is often referred to as the 6-3-3-4 system of education and characterizes the current (1991) structure of Nigerian Educational Policy which suggests six years for primary schooling, three each for junior and secondary schooling, and four for a standard university degree. The junior secondary school stage started operating throughout Nigeria in 1982.

Student characteristics in the science schools are reflected in the nature of the selection procedures. Over the fourteen years the science schools project has been in operation (1977-1991), two distinct strategies were adopted in the student selection procedures. The first procedure was used between 1977 to 1988. The second procedure was initiated in 1989, and became fully operational in January 1990.

Under the first procedure at the beginning of the project in 1977, students considered academically good in Form II in all secondary schools in Kano[3] were given a selection examination and those who passed are placed in the science schools where they continue with Form III. The science schools therefore started as senior secondary schools right from inception.

To ensure the selection of the students was carried out along the lines envisaged by the Board, a sub-committee (the Tests Committee) was set up within the administrative structure of the Science Board which worked out the selection process for the then two science schools (both for boys; the girls school was introduced first in 1981). This Committee gradually metamorphosed into an Academic Committee in 1979.

To complement the Academic Committee, the Science Board also employed the services of the West African Examinations Council to conduct selection examinations for the schools for the first three years of the project, after which the Board took over and started conducting its own selection examinations.

The selection process was crucial to the entire science secondary schools project for a number of other reasons, not the least of which was the effect it had on the schools where the students were to come from. As the Principal of a feeder school explained:

> "Believe me, not me alone but many people, the teachers, you see are grumbling that the best students have been taken away and as such nobody should blame us for having very bad students, because the best ones who could help the remaining who are not as good as these ones have been taken away.

3. At that time the National Policy on Education described in Footnote 1 had not been fully introduced, and secondary schools in Nigeria operated a five-year school system which was unfragmented.

> There is nothing we can do about this. This is a government project and they can do whatever they want." (Interview 30 September 1986).

Subsequently, however, some of the principals in the feeder schools responded to the situation by substituting their best students for the less than average which were requested to sit for the selection examination. The Science Board discovered this quickly, though, because as a principal said:

> "We cannot even substitute good students for bad students during the selection. These people come from the Science Board and they try to examine the files of my students and they may like to see my students physically. We have to be honest in this. This is an annual event, you know. Every year there will be a letter from the Science Board telling us that there is going to be a selection exercise. And then there are many students who would like to go to these schools because they feel that the science secondary school is better than any school in which they are." (Interview 30 September 1986).

In their objections, the principals of the feeder schools provided two arguments to support their rejection of the selection procedure. First, if their best students were taken away from them, then it was likely that only the worst students would be left behind. And if the GCE examinations were bad, the schools would be blamed (this is a traditional government response to bad examination results). This latter practice has become more prevalent since some states in Nigeria started grading principals according to the success of their students in the SSCE[4] Ordinary level examination results. A situation where a large portion of

4. The Senior Secondary School Certificate Examination (SSCE) was introduced in 1988 to replace the former General Certificate of Education (GCE) ordinary level examination at the terminal stage of senior secondary schooling in Nigeria. Due to the enhanced nature of the curriculum which gave rise to the SSCE, the examination is often considered more 'difficult' than the GCE (which was restricted only to private candidates). The graduates of the SSCE, unlike those of the GCE, are eligible for direct entry into first year degree programmes in Nigerian Universities, after passing an intermediary examination, the Joint Matriculation Examination (JME).

the student population produces poor results makes many principals in Kano rather nervous, especially as there is a government tendency to blame the schools for such failures.

Secondly, some principals argue if it is true that the science schools are special in the sense of having better equipment, teachers and other facilities, then it makes more sense not to select the best students from the feeder schools who, if they are good anyway would succeed no matter where they are. It would be strategically better, according to this argument, to take students who are less than average, but very likely with latent abilities in science and given the good environment of the science schools to develop it. In this way, the conventional schools will develop their good students, and the science schools will enable students with latent abilities in science to manifest themselves to the benefit of everyone.

Thus the lack of a clear working link between the science schools project and other educational services and contexts in Kano, has contributed to a considerable amount of difficulty in stabilizing the project, especially at its outset.

3.1.2 Selection of students - the first stage: 1977-1988

At the beginning of the science schools project in 1977, cohort students were selected from the 'best' schools in Kano. Such schools tended to be located in, or close to, Kano City. This, it was subsequently realized, denied a significant number of students the chance of being selected into the science schools. As a result of this, three years after the project was started, the Kano State Government decided to provide a greater opportunity for all students to have a chance of being selected into one of the science schools, regardless of domicile. As a Senior Assistant Secretary in the Science Board guardedly explained:

> "In 1980 the Commissioner of Education said we have to reflect each local government in Kano in our selection of students. We must have a student from each local government. So after we complete our admission then we have to break it into local governments." (Interview 3 October 1986).

This step was also taken to allay any opposition to the selection of students from metropolitan schools which tended to give the impression of being the best, both in terms of infrastructure and academic capabilities.

3.1.3 Student characteristics

Due to the specialist nature of the science schools, there were feelings that they would cater only for elitist children (Adamu, 1988). This is an interesting point in that it will ultimately determine the tone of the schools. The point is pursued further in this sub-section.

It has been contended that in educational research, the occupation of the student's father 'is one of the most commonly used indicators of the socio-economic level of the home' (Keys 1987, p.37). To determine the socio-economic characteristics of the science school students, a random sample of 300 in four of the science schools were asked to provide information about themselves, including parental occupations and education through a questionnaire (for details, see Adamu 1988). The findings should be of significance because at the beginning of the science schools project, one of the most consistent criticisms against it was such schools would only cater for the children of Kano State elites through the selection examination.

And yet if paternal occupation could be taken as a socio-economic indicator of status, then the expectations of elitism does not seem to apply to the science school students in the sample. This is suggested by *Table 2* which summarizes the free response results of students' paternal occupations. To condense the analysis, only the paternal variables are considered in all discussion of the students' characteristics.

A limitation of this table is the unavailability of data on occupational norms for Kano State which could show the real distribution of these occupational categories, and subsequently indicate whether any category is over-represented here. However, from the table, it would appear the predominant paternal occupation is farming, accounting for 64.5 per cent of the total responses. In Kano State, the farming job category is commonly associated with independent subsistence status, and not linked with advanced academic training.

Table 2. Fathers' occupation by domicile (N=281)

Occupation category	City	Town	Village	Total	%
Farmer	19	67	96	182	64.5
Civil servant	21	19	2	42	14.9
Businessman	20	9	5	34	12.1
Teacher	7	5	1	13	4.6
Manual labour	4	3	0	7	2.5
Doctor	1	0	1	2	0.7
Engineer	1	0	0	1	0.4
Total	73	103	105	281	100.0
Percentage	25.9	36.5	37.3	100.0	--

Source: Adamu 1988. *Science, schooling and manpower production in Nigeria: a study of Kano State science secondary schools, 1977-1987.*

Even the distribution of the job categories in domicile is residentially stratified. For instance there were more farming occupations in the villages (96) than in the city (19) or towns (67). The table therefore suggests some relationship between paternal occupation and domicile, with children of the more modern sector professionals living more in the Kano Metropolitan City[5], than in its suburbs.

The findings suggested by *Table 3* therefore discount the expectation that a facility such as the science secondary school may be used to cater for the children of the few socio-politically powerful individuals in Kano State, so long as merit remains the main decisive factor in the selection of the students.

5. Kano is actually a City-State, with the main capital of the State being concentrated in a huge sprawling metropolis. The rest of the State is made up mainly of towns and villages, differentiated by their low level of urbanization and presence of modern facilities.

However, studies undertaken earlier than 1988 indicate some form of apparent bias towards favouring the socio-economically well-off student population in the schools. In a study of the criteria of selection into the science schools, Ekuh (1984) discovered that:

> "...the science secondary schools students were from urban areas... This ties up with the finding that these science secondary school students came from more affluent homes." (Ekuh 1984, abstract p.*x*).

It was as a result of findings like these, that the Science Schools Board subtly reformed its selection procedure in its first stage to deliberately ensure that every student from Kano State, regardless of socio-economic or residential status, had an equal chance of being selected for placement in the science secondary schools.

3.1.4 Selection of students - the second stage: 1988-1990

However, by the mid-1980s the science schools students had started making an impact in the Nigerian higher educational system, and this has led to a re-assessment of the schools by both the Ministry of Education and other organs of the Kano State government.

It emerged that the greatest problem faced in the entire science schools project was that of poor performance in the English language of the previous students of the schools (see Chapter 4). This was because at the initial stages of the project, the number of teaching periods allocated to English was not made different from those allocated to other non-science subjects. Indeed, liberal arts subjects were seen as being auxiliary to the central purpose of the schools -- the teaching of science. By the mid-1980s, when the products of the schools started finding difficulties in getting admitted into tertiary institutions to study science and technology disciplines on account of their poor performance in English language (despite having met all other entrance requirements), the Science Board was forced to reform the student selection procedure and emphasize English language.[6]

6. Passing English language at the General Certification of Education, now replaced by the Senior Secondary School Certificate ordinary level examinations is a compulsory requirement for entry to tertiary institutions in Nigeria.

The Science Board, worried about a huge number of students with good grades in science subjects but unable to gain admission into most universities, especially in southern Nigeria, due to their failure in English language, commissioned a study on the nature of English language teaching in the science schools on 19 October 1988. The report, submitted to the Board on 5 December 1988 identified a number of reasons for such poor performance in the subject and provided the Board with a framework for re-structuring the selection exercise. These reasons included:

(a) Inadequate pre-entry preparation, where it was discovered that many of the students come to the schools with a very poor knowledge of English. Some of the teachers 'claimed that some SS1 students could not write or speak a single sentence of English at entry.' The report suggested that the selection procedure adopted by the Board ought to be so sensitive as to be able to weed out such semi-illiterate candidates from being accepted into the science schools.

(b) Poor attitudes of students towards English. As the report noted, 'most of the science students think English is a nuisance with which they do not wish to be bothered.' Some are complacent about their own competence in it, while others simply do not think it worth their while to work hard at it.

(c) Poor attitudes of teachers towards English. The report further noted that the attitude of other teachers towards English did not encourage students to learn it. It was alleged that some 'teachers used Hausa (the local language) as a medium of instruction instead of English in some subjects.' It was also reported that 'communication between teachers and students outside the classroom invariably took place in Hausa to the detriment of English. Also, although other teachers do recognize that poor English contributes to the negative performance of students even in science subjects (where essay questions are asked), they do nothing to encourage students to work harder at their English.'

The commissioned study made a series of other recommendations which contained, in substance, the solutions to the problems raised above. The Board, according to a decision taken in May 1989 changed its entrance examinations (i.e. the selection process) into a three-stage procedure with effect from November 1989.

In the first stage, virtually all the students from the selected Junior Secondary School III classes in various secondary schools in Kano were given a first screening examination in English language, and a high pass mark set for this examination. Those who failed this initial English language examination were automatically eliminated from participating further in the selection procedure.

In the second stage, only those who passed the English language examination at the required level (determined by the Board according to the mean performance of the candidates) were allowed to sit for the main selection examinations which involved taking examination papers in science and mathematics subjects, both also set at a high pass standard.

Once this was completed, then the third, and final stage of interviewing each short-listed student in English language was conducted. Only those who survived these three stages were placed in the five science secondary schools in Kano State.

At the time of writing this monograph (February 1991), the effect of this strategy has not yet been measured since the senior school certificate examination results of the first products of this experiment (termed English Improvement Project by the Science Board) will only be known in mid-1993.

3.2 Operation and efficiency in the science schools

3.2.1 Students, teachers, subjects and populations

While it is perfectly normal in non-science schools, to find about 40 to 50 students per classroom (meant to accommodate, at most, 30 students), there have been determined attempts by the Kano State Government to ensure that the science schools are not overcrowded or understaffed. To this end, a constant average ratio of at least one teacher for every 20 students in all the school subjects (but with emphasis on compulsory core science subjects) in the science schools has been steadily maintained in the fourteen years the project has been in operation. The maintenance of this ratio is indicated in *Tables 3.a* and *3.b* which shows the ratio of students and teachers in all the five science schools of Kano State in August 1990.

Table 3.a. Teaching staff and strength in Kano State science schools 1990

School	D/Kudu	D/Tofa	K/Hausa	Taura*	Jahun*	Totals
Streams	22	22	22	12	18	96
Biology	6	4	6	5	3	24
Chemistry	6	3	6	4	4	23
Physics	5	6	5	3	2	21
Mathematics	7	8	6	3	3	27
Geography	7	6	7	3	5	28
English	7	7	10	5	5	34
Agric. science	3	4	3	-	-	10
Tech. drawing	1	1	1	-	-	3
Science	42	39	44	23	22	170
Hausa	2	3	2	3	3	13
Islam	3	3	3	2	2	13
Home Economics	-	-	-	2	3	5
Grand Total	47	45	49	30	30	201

* Girls' Science Secondary Schools.

As *Table 3.b* shows the ratio of teachers to students is certainly within tolerable limits for what one might adjudicate as comfortable teaching circumstances; little over-crowding, and adequate classes for the student population in the schools.

A more detailed study of the documents from which this information is extracted indicated that the least qualified teachers in the science schools were those with the National Certificate of Education qualification (products of Colleges of Education). This category of teachers are those who teach the arts subjects. The science teachers have qualifications ranging from B.Sc, Higher National Diploma (HND), Post Graduate Diploma in Education (in addition to a B.Sc degree in a science subject), and M.Sc qualifications in pure science subjects. Interestingly, very few (about 3 per cent) had teaching qualifications in science education (i.e. were actually trained as science teachers).

Table 3.b. Science teaching staff and strength of Kano State science secondary schools 1990

School	Year	Gender	Streams	Population	Teachers	Ratio
D/Kudu	1977	Boys	22	720	42	1:17
D/Tofa	1977	Boys	22	720	39	1:18
Taura	1981	Girls	12	486	23	1:21
K/Hausa	1985	Boys	22	420	44	1:09
Jahun	1987	Girls	18	500	22	1:22
Total			96	2 846	170	1:16

Source: Kano, Science and Technical Schools Board documents.

With regards to actual periods or exposure to science teaching, the Science Board recommends (and implements) that all the science schools should teach biology, chemistry, and physics, for five periods a week each. Since each period in the science schools lasts for 40 minutes this means a total of 600 minutes or ten hours for the three subjects per week. In the Kano State science schools, two of the five periods for each of the three main laboratory-based subjects (biology, chemistry and physics) are devoted to practical teaching, while the remaining three are used for 'theory' teaching. This has been the standard tradition in science education in Kano since 1960 -- teaching science subjects at alternating 'theory' and 'practical' periods; a practice which the new science curriculum produced by the federal government in 1985 strongly discourages.

English, mathematics and further mathematics are allocated six periods each (total of 720 minutes or 12 hours), while geography is given four periods per week. Thus the main subjects in the science schools (biology, chemistry, physics, mathematics, further mathematics and

English) occupy 1,320 minutes or 22 school hours per week. These are completely maintained, because as *Tables 3.a* and *3.b* show, the schools have both the physical structures (especially the classes) and the teachers for this.

Other subjects offered to the students are Hausa and Islamic religious knowledge (three periods a week each). In addition, three electives out of which a student must make a choice of one are offered; a choice of either technical drawing or agricultural science (five periods per week each) only to the boys, and home economics (five periods a week) only to the girls.

3.2.2 Monitoring the quality of science education

To ensure that teaching and learning in the science schools conforms to the standards set by the Science Schools Board, an Inspectorate Division was created in April 1987 within the Science Board structure, and headed by a Director who is responsible for the professional (i.e. academic) standards of the schools under the Science Board. The Inspectorate Division is therefore the sub-unit of the Board that is responsible for the operation and efficiency of the schools. It also conducts the interviews during the recruitment of teachers (with the minimum qualification being a Bachelor's degree in science for teaching in the science schools).

The Inspectorate Division conducts three broad types of inspection in the science schools: Administrative, Academic and Teaching. Each aspect of the school covered under this broad division is closely inspected by a team assembled from both the administrators at the headquarters of the Science Board and teachers from schools other than the school to be inspected.

The Administrative inspection is directed at the principals of the schools and attempts to determine the extent to which the schools are efficiently run in terms of costs, records, regularity of staff meetings, problem cases among both teachers and students, admission records and so on. The Administrative inspection provides an overall picture of the school.

Suggestions are often given by the team of inspectors to any problems the team discovered. A follow-up by the team to determine the effectiveness of the suggestions with regards to the problems is conducted within two weeks of the first visit.

The Academic inspection aims itself at the Heads of respective departments within the schools, and concentrates on the availability of teaching material vis-à-vis the student population. Records of teaching kept by the Heads of departments for their respective teachers are also inspected. But most importantly, the performance of the students both in external and internal school-based examinations are closely analysed, and explanations sought in cases where the Board feels there is an unacceptable degree of failure on the part of the students.

The final focus of the inspection team in determining the efficiency of the science schools system is the Teacher. The Science Board recruits only graduate science teachers in the main science disciplines of chemistry, biology, physics, geography, mathematics and English. Teachers with lesser qualifications are not sent to teach in the science schools, but posted to technical schools (also under the Science Board). Further, the Board adopted a policy of deliberately not employing teachers whose qualifications might make it easy for them to work in the industrial sector of the Nigerian economy - such as biochemists, geologists, pharmacists (although, strangely enough, some graduates with these qualifications actually do often apply for consideration as teachers).

The teacher inspection team normally goes into a class with a subject teacher from another school as well as the head of department of the teacher being inspected. The teaching is evaluated using an expected teaching plan and structure, designed and approved by the Science Board. The main focus is often on the content validity of the information given to the students, and a fairly flexible judgement of how effective the contents are taught to the students, the nature and frequency of assignments given to the students, the record of work kept by the teacher and the rapidity with which the curriculum is covered. The main guide in the teaching inspection is the National Curriculum adopted for that subject as approved by the Federal Ministry of Education, Nigeria.

3.2.3 Observations of teaching processes in the science schools

In attempting to gain more understanding of how all these factors affect science teaching and learning in the science schools, as well as gain insights into the mechanism of the processes, one of the analytical strategies of the above-mentioned research was a series of classroom observations of teaching in biology and physics lessons in two of the science schools. Part of the result of this observation is summarized in *Table 4*, which records the teaching emphases of seven biology and physics teachers observed in the science schools during 17 lessons (ten physics, seven biology).

The teachers' emphasis during science teaching actually reflects the Nigerian science curriculum, rather than its rhetoric. For instance, in the introduction to the biology curriculum, it was urged by its developers:

> "In accordance with the stated objectives, the contents and context of the syllabus places emphasis on field studies, guided-discovery, laboratory technique and skills, coupled with conceptual thinking. So teachers are strongly encouraged to employ the student-activity based on an inquiry mode of teaching." (Nigeria 1985 (Biology curricular guidelines, p.ii).

But an analysis of the curriculum reveals that of the 754 individually stated performance objectives in biology, chemistry and physics, 682 or 90 per cent belong to the cognitive domain, while the remaining 70 are psychomotor. None were in the affective. Similarly, of the 316 cognitive objectives of biology, 203 or 65 per cent were knowledge-based, 104 or 32 per cent aimed at comprehension, while only 9 or 2.8 per cent were aimed at application (Adamu 1989). In physics, 92 performance objectives out of a total 203 (45%) aimed at knowledge, 91 (44%) comprehension and 20 (9.8%) application (Adamu 1990a).

Table 4. Teaching biology and physics in science schools by frequency of observation and time spent

	Number of 5 minute durations per category					
Category	Biology	%	Physics	%	Total	%
1. Settling down	15	14.1	16	10.0	31	11.7
2. Teacher talks and						
introduces topic	12	11.3	13	8.1	25	9.4
reviews topic	7	6.6	14	8.7	21	7.9
expands explanation of topic	86	81.1	103	64.3	189	71.5
3. Students ask questions	1	0.9	0	0.0	1	0.3
4. Teacher ask questions	6	5.6	7	4.3	13	4.9
5. Teacher refers to text	0	0.0	0	0.0	0	0.0
6. Teacher writes on board for students to copy	21	19.8	16	10.0	37	14.0
7. Teacher demonstrates activity	0	0.0	5	3.1	5	1.8
8. Students carry out activity	0	0.0	5	3.1	5	1.8
9. Class discussion of activity	0	0.0	0	0.0	0	0.0

Source: Adamu 1988, 1990b.

Thus with a predominant, albeit possibly unintended, emphasis on knowledge domains in the science curriculum, it is not surprising that science teachers spend between 60-70 per cent of teaching time in predominantly verbal exposition as indicated in Table 4. This is similar to the findings of Lewin (1981, 1984b) on science teaching in Malaysia and Sri Lanka who observed:

> "Less than 16 per cent of the classtime was spent with pupils actually undertaking experimentation as the main activity. Most classtime -- over 32 per cent -- was spent with the teacher addressing the class as a whole... Thus considerable time was spent in class discussions introducing new information and concepts, and the greatest single number of

> observations occurred when teachers were requiring pupils to recall such information. Further analysis of the observation data indicated that the 'guided discovery' approach recommended in course materials was used by very few teachers. For example, on no occasion were pupils observed contributing to the design of experiments, and they were rarely asked to hypothesize, predict, interpret or infer." (Lewin 1984b, p.140).

From both the strategic emphasis of the teachers during the lessons in the science schools, and the opinions expressed, it was clear that not all teachers share the same pedagogical views of science teaching objectives as those of the developers of the new science curriculum. In effect, teachers' qualifications and support services in the science schools have never really kept pace with the expectations of the Nigerian Science Curriculum. As a teacher in a science school said concerning the objectives of the Nigerian Science Curriculum:

> "They are not realistic, because if you follow the set-down objectives, as far as the new science curriculum is concerned, you find that it is too demanding, too demanding. It is demanding on the teacher, and even demanding on the people concerned -- people who set the objectives! Surely if they are asked to bring all the necessary things which will help in achieving the objectives, I know they cannot do it. You see so many demonstrations which you need to do, but when you look around you can't find what to demonstrate with." (Interview 25 February 1987).

Further, some Science Board officials are not convinced that instructing or requesting science teachers to teach science in a specific way (e.g. as suggested in the new science curricula) without taking the necessary support measures would be useful. As an official stated, there would be quite a few problems:

> "...if you recommend a particular technique (of teaching science to the teachers). It may not be known to the teachers. You have to realize that in Nigeria today, it is not all teachers

who are in the classroom who are actually teachers. They don't even have the basic qualification for teaching." (Interview 26 September 1986).

Thus while the emphasis of the Science Board is on getting what it considers the best teachers, -- about 75 per cent of the recruited teachers were degree holders -- (Science and Technical Schools Board, 1988) the criteria for determining this quality are not necessarily linked with specific teacher training in science consistent with proper interpretation of the science curriculum in the schools.

However, lack of sharing of common purposes between the science teachers in the science schools and the curriculum is not surprising, since the policy-makers' primary rationale in setting up the science schools was borne out of a concern to increase the number of students from Kano with a science background rather than to improve the quality of science teaching and learning.

3.3 The management of science education in Kano State science secondary schools

The Science Board has two main sources of obtaining funds. The first is from subventions received from the state government through the Ministry of Finance, and the second is through revenue collection (school fees -- nominally charged as the state subvents education for all its indigenes -- examination fees, tender fees etc.).

Maintaining a system like the science schools in a depressed and developing economy requires considerable prudence and innovation in financial management. This is all the more so as the capital for the execution of most projects in the science schools was, up to 1987 controlled by the Commissioner of Education (Ministry of Education), even though the Science Board was not part of the Ministry of Education, but an independent parastatal.

However, in August 1987 the capital vote for expenditure was handed over to the Board directly by the Kano State Government. This made it possible for the Board to set up a Works Division (which liaises with the Chief Engineer, in the Ministry of Education, Kano) and commence equipment production (Science and Technical Schools Board, 1987).

As a standard, each of the five science secondary schools has eight laboratories: two each for biology, chemistry and physics, and one each for geography, technical drawing and home economics, the last two present in boys' or the girls' school as appropriate. This means that materials for these laboratories have to constantly be replenished, and furniture often replaced, and more updated books have to be purchased.

With the return of the capital vote to the Science Board in 1987 and an earlier merger of the science schools management with technical schools in Kano in 1982 (Kano State 1982), the Science Board seized the opportunity of its control of the technical schools in Kano and took over one of the workshops of the Kano Technical School (the oldest in the state, being established in 1953) and used it as a basis for a local equipment production centre, not only in science teaching but also for general maintenance of the buildings of the schools.

This became necessary because by then the Nigerian economy had taken a sharp down-turn and the subvention to the Board reflected this change of circumstances. Foreign exchange became more strictly regulated by the government and subsequently more difficult to obtain. This considerably limited the extent to which the Board could buy materials from outside the country. With no alternatives, and committed to a large number of laboratories, the Board's decision to create its own Equipment Workshop was seen in the mid-1980s as the most viable strategy in reducing the high cost of specialist science education in the state. By 1990 this strategy has produced considerable results. For instance, most of the laboratory furniture in the science, technical and vocational schools under the Science Board was produced from the Equipment Workshop of the Science Board. Items such as test-tubes, test-tube holders, weather stations, fume cupboards, metre rules and bridges are quite easily produced by the Workshop and distributed to the schools as needed.

There are materials, of course, that cannot easily be produced by the Equipment Workshop, such as chemicals. The Board's replenishment of these items is normally initiated by requirements for the Senior Secondary School Certificate Examinations. During this final year (SS III) the West African Examinations Council that conducts the examinations normally sends a list of equipment and materials needed for its practical examinations to the science schools. The science schools then pass these lists to the Science Board. Those that can be constructed at the Technical Equipment Workshop are easily produced and sent to the schools. Those that have to be bought are done so from a vote of the Board. Not only are savings made on the cost of purchasing these items and sending them to the schools, but little delays are caused in the students' learning.

Chapter 4

Purpose and outcomes of the science schools

A discussion of the outcomes of any developmental policy is not possible without some qualifier. This is because outcome has a different meaning for an analyst and a policy maker. In the policy maker's perspective, the term outcome is used to emphasize the successes of the policy, based on its stated objectives; and the major objective in Kano State has been to increase the number of science students produced by the secondary schooling system (through special provisions in Kano State) who proceed to tertiary institutions and graduate in science and technology disciplines.

This basic objective therefore gives two areas of analytical focus: the first is the number of science-based secondary level graduates produced by the science schools since their establishment; the second is the placement of these students in science and technology disciplines in higher institutions, as well as in the labour market. The specific indices of measurement of these outcomes would be: examination outcomes (in terms of pass rates in science subjects among the students), enrolment of the students in tertiary institutions (in terms of the science school students who are admitted to study science and technology disciplines), and the extent of their absorption into the labour market after their tertiary training (in terms of their employment in the science and technology sectors of the Nigerian economy).

4.1 Examination outcomes

The first analytical focus asks to what extent has the establishment of the science schools made any difference to the number of GCE science graduates from Kano? This is difficult to answer totally without accurate information about the number of science graduates produced by secondary schools in Kano State before the establishment of the science schools.

However, according to figures made available by the Science Board, an average of 4,353 science students from the science schools have graduated between 1980 and 1989 in six core science subjects; geography, chemistry, biology, physics, mathematics, and English.[7] And from various discussions with policy initiators of the project, this alone justifies the establishment of the project since this number far exceed the number that all the conventional secondary schools have produced since the establishment of Kano State in 1968.

But a more important measure of success of the project is provided by the Nigerian General Certificate of Education Ordinary Level examination results of these students. The results, from four of the schools that have submitted candidates in the West African Examinations Council General Certificate of Education examination from 1980 to 1989 -- ten years inclusive -- at various years (Dawakin Kudu (1980), Dawakin Tofa (1980), Kafin Hausa (1988) all for boys, and Taura (1984) for girls) are shown in *Table 5*.

These subjects are chosen for analysis because they constitute the main and compulsory subjects any student wishing to study any science and technology discipline in any Nigerian university has to pass at a credit level (as opposed to pass) at the ordinary level examinations. The table indicates a mean credit level achievement rate of 33 per cent in the six core subjects from a mean number of 4,353 students over ten years since the students in the schools started taking external examinations.

However, many students obtained a combination of credits and passes in all subjects. This category of students are usually those admitted into Polytechnics to study science and technology disciplines leading to an award of Nigerian Ordinary National Diploma (OND) after

7. The mean figure of 4,353 is a consolidated mean; it refers to the total number of students listed as having taken examinations in six core subjects shown in *Table 5*, divided by 6. The means indicated in *Tables 6* and *9* are also obtained by adding the total number of students (first row of figures in any of the tables) and dividing that by the total number of subjects listed in the table. It is used purely as a statistical variant to reflect a *trend*.

three years, after which they can proceed for a Higher National Diploma programme if they so wish after passing the OND at the appropriate level, and after gaining work experience for at least one year.

Table 5. Science schools GCE ordinary level examination results in core science subjects 1980-1989

Subject	Number	Credits	%	Passes	%	Fail	%
Geography	4 168	2 074	50	3 030	73	1 138	27
Chemistry	4 405	1 650	37	3 012	68	1 393	32
Biology	4 403	1 609	37	3 124	71	1 279	29
Maths	4 403	1 526	35	3 005	68	1 398	32
Physics	4 401	1 226	28	2 459	56	1 942	44
English	4 338	474	11	1 518	35	2 820	65
Mean	4 353	1 427	33	2 691	62	1 662	38

However, many students obtained a combination of credits and passes in all subjects. This category of students are usually those admitted into Polytechnics to study science and technology disciplines leading to an award of Nigerian Ordinary National Diploma (OND) after three years, after which they can proceed for a Higher National Diploma programme if they so wish after passing the OND at the appropriate level, and after gaining work experience for at least one year.

One area of concern to the policy initiators of the science schools is the dismal performance of the students of the schools in English language -- a pre-requisite entry qualification to Nigerian tertiary educational system (see Chapter 3).

Thus the overall pass rate of the students from the science schools in the ten year period indicates an average of 62 per cent success rate, with only 38 per cent failing totally in these six core subjects. Policy makers point out that this is a remarkable achievement, especially against the overall performance of all the schools in Kano State in science subjects in the final senior secondary school ordinary level examinations. To illustrate this, the results of the 1989 Senior Secondary School Certificate examination performance in science in the whole of Kano State secondary schools are shown in *Table 6.*

Table 6. General performance of Kano State students in science subjects in SSCE ordinary level examination, 1989

Subject	No	Fail	Pass	Credit	% CRDT
Agricultural Science	5 096	3 574	931	591	11.5
Chemistry	2 517	2 004	361	152	6.0
Physics	2 496	2 181	194	121	4.8
Mathematics	8 028	6 139	1 580	309	3.8
Further Maths	123	96	23	4	3.2
Technical Drawing	413	321	81	11	2.6
Biology	7 464	6 779	592	93	1.2
English Language	7 953	7 678	253	22	0.2
Mean	4 261	3 596	501	162	4.1

Source: Kano State. 1990. *Statistics of examination performance of students in Kano State secondary schools in the 1989 Senior Secondary School Certificate Examinations.* Kano, Ministry of Education. July 1990.

Interestingly enough, Ubale (1986) who compared the examination results of the first batch of students from the science secondary schools (class of 1980) and four schools in Kano under either total or partial control of the Kano State Ministry of Education, discovered that:

> "...the first four batches of students that graduated from the Science Secondary School for boys and the first batch of the Girls' Science Secondary School (1985) did not perform any better than science students that graduated from the other secondary schools under Kano State Ministry of Education." (Ubale 1986, p.78).

However, results like those presented in *Tables 5* and *6* show that the results obtained from the science secondary schools have continuously and significantly improved over the last years.

The relatively high achievements of the students of the science secondary schools (compared with those of 'ordinary' schools) do not stop with core science subjects only. A similar trend is indicated where all the subjects offered to the students are taken into consideration. This is shown in *Table 7*.

Table 7. Science schools GCE ordinary level examination results of science secondary schools in all subjects, 1980-1989

Subject	Number	Credits	%	Passes	%	Fail	%
Haisa	2 162	1 778	82	2 080	96	82	4
Islamic religious knowledge	3 557	2 376	68	3 153	89	404	11
Tech. drawing	1 323	723	55	1 156	87	167	13
Geography	4 168	2 074	50	3 030	73	1 138	27
Agric. science	2 237	1 023	46	1 951	87	278	13
Home economics	481	193	40	425	88	56	12
Further maths	620	233	38	475	77	145	23
Chemistry	4 405	1 650	37	3 012	68	1 393	32
Biology	4 403	1 609	37	3 124	71	1 279	29
Maths	4 403	1 526	35	3 005	68	1 398	32
Physics	4 401	1 226	28	2 459	56	1 942	44
English	4 338	474	11	1 518	35	2 820	65
Mean	3 042	1 240	41	2 116	70	925	30

When compulsory liberal arts subjects (Islamic religious knowledge (I.R.K) and Hausa language), as well as electives (home economics for girls only), technical drawing, agricultural science and further mathematics (for the boys only) are added to the core science subjects, the results are, perhaps not surprising, raised to a mean pass rate of 70 per cent (out of an average number of 3,402 students) in all the subjects in ten years since the science schools started providing candidates for external examinations in 1980. Only 30 per cent (mean = 925) out of the mean number of 3,042 actually failed in their subjects. And in all the subjects, a mean number of 41 per cent obtained credit level passes.

However, to obtain the trend in all the science and technical oriented disciplines, another table was computed which shows the results of the students in science and technical subjects, as indicated in *Table 8*. This table shows the output of students who would be programmed to study 'white-collar' science subjects as well as those the government hopes would study other science-based subjects such as engineering, environmental design, etc..

Table 8. Science schools GCE ordinary level examination results, 1980-1988: science and technical subjects only

Subject	No	Credit	%	Pass	%	Fail	%
Geography	4 168	2 074	50	3 030	73	1 138	27
Chemistry	4 405	1 650	37	3 012	68	1 393	32
Biology	4 403	1 609	37	3 124	71	1 279	29
Maths	4 403	1 526	35	3 005	68	1 398	32
Physics	4 401	1 226	28	2 459	56	1 942	44
English	4 338	474	11	1 518	35	2 820	65
Agric. science	2 237	1 023	46	1 951	87	278	13
Tech. drawing	1 323	723	55	1 156	87	167	13
Further maths	620	233	38	475	77	145	23
Mean	3 366	1 170	35	2 192	65	1 173	35

As *Table 8* shows, a clear trend of over 65 per cent passes in the subjects that matter to the science school students is maintained. Only 35 per cent of the students failed totally in the main subjects considered necessary for an advanced study in science and technology disciplines. These subjects included agricultural science, technical drawing and further mathematics. A similar number, i.e. 35 per cent out of the total mean of 3,366 obtained credit level results in these main subjects.

It is interesting to note the high rate of passes in subjects that are not science-related (e.g. Hausa language, Islamic religious knowledge) among the science school students. These subjects were, at the beginning of the Science Schools project in 1977 considered electives; however, in 1985, the Kano State Government made their study compulsory in all its secondary schools. Being culturally related (language and religion), they tended to evoke more commitment on the part of the students since failure in them would be interpreted as failure in understanding basic cultural tenets.

While the entire science schools project itself is quite innovative in the study of any educational change strategy in both developed and developing countries -- for instance, it was the first of its kind in Nigeria -- the inclusion of girls' science schools as part of the project makes it more interesting, especially in the face of the growing international concern about the lack of representation of women and girls in science education, and science and technology disciplines. This is even more so in a very traditionally conservative society such as Kano. So the vital question is, how well did the Girls' Science School fare? This is answered in *Table 9* which shows the results of the girls' science school Taura[8] from 1984 when they started offering GCE ordinary level examination to 1989.

Although the female students offer geography, mathematics and physics -- good combinations for astrophysics, geology, aeronautical engineering, mining engineering etc., their relatively low achievements in physics and maths and relative successes in biology and chemistry would seem to steer them more towards nursing and catering professions than hard core sciences. Furthermore as *Table 9* shows, although there was an overall mean pass rate of 55 per cent in all the nine subjects offered, this was not because of their achievement in the science subjects. The four most successful subjects in the girls' science school were Hausa, Islamic religious knowledge, geography, home economics -- hardly a combination for mining or aerospace engineering.

Science subjects -- the main reason for setting up the school -- rated low achievement percentages ranging from 20 per cent credit level in chemistry to 19 per cent in biology and 17 per cent in physics.

8. At time of writing the other girls' science school, Jahun, had not produced students capable of sitting the external examinations.

mathematics and English rated the lowest with 12 per cent and 8 per cent credit achievements respectively. The overall mean results in science were not encouraging. Only 17 per cent of the students got credit level achievements in the six core science subjects, 38 per cent achieved the pass level (which, as explained before included those with credit level passes) and a majority of 62 per cent failed in these vital subjects.

Table 9. Taura girls science secondary school summary of GCE O level examination results, 1984-1989

Subject	No	Credit	%	Pass	%	Fail	%
Geography	375	108	29	201	54	174	46
Chemistry	502	99	20	216	43	286	57
Biology	504	95	19	248	49	256	51
Physics	504	86	17	164	33	340	67
Maths	498	59	12	149	30	349	70
English	502	40	8	106	21	396	79
Mean	480	81	17	181	38	300	62
Hausa	502	295	59	472	94	30	6
Islamic religious knowledge	504	231	46	438	87	66	13
Home economics	481	193	40	425	88	56	12
Mean	496	240	48	445	90	49	10
Total mean	486	134	28	269	55	217	45

These results provide a basis for many possible interpretations. One of them rests on the assumptions that deal with the intellectual capabilities of girls, whatever their social and economic background. For instance, Ferguson (1981) noted that in more scientific terms, the suggestion is that girls are not able to 'do' science well because of biologically determined inferior mathematical and spatial-visual abilities, and that efforts to improve their participation are futile and misdirected. This particular thesis has not provided a definitive basis for generalization, especially in socio-cultural environments such as those similar to those in Kano State.

However, one of the Science and Technical Schools Board officials commented about the results of the Girls Science School in 1984:

> "It is gratifying to note that 18 girls out of the 65 that sat for the GCE ordinary level examinations (in the Taura Girls Science School) obtained five credits and above; thus qualifying for direct university entrance." (Interview 18 October 1986).

It is worthwhile noting indeed, that by 1987 over 500 girls had graduated from the first girls' science school (Science and Technical Schools Board, 1988). In this figure the Kano State policy initiators of the project see the girls' science schools as something of an achievement: creating a learning context where over five hundred girls from a predominantly conservative Muslim State such as Kano State learn the main core science subjects on a non-option basis necessary for scientific and technological career advancement.

However, it is quite clear that to make science education more functional for girls in Kano, and to make the girls' science school live up to its expectations of being a science school, wider and more scientific curricular offerings must be made available to the students. For instance, agricultural science should be given serious consideration. If the stereotype of the role of women in the society must be maintained by the Science Board, then this subject might make it possible for the students to apply knowledge of agricultural practices at home. But generally, if the policy initiators of the project are convinced of the value of girls' science education, then there is no reason why the girls should not be given the same curricular offering as the boys. After all, the girls' science schools were established on the same equal intellectual footing as the boys' schools.

But whatever the analytical interpretation given to these results, the figures do indicate the production of a large number of science-based graduates, which was made possible by the establishment of the science schools in Kano. This has led to a considerable degree of satisfaction by

Science Board officials and school authorities that the science schools project has produced the required number of students to proceed to higher institutions to study science and technology disciplines.

4.2 Further education outcomes

The second analytical focus asks, to what extent has the establishment of the science schools made any difference to the science and technology manpower status of Kano State? As with the first focus, this also has its problems, not the least of which is that follow-up services do not exist within the Science Board which would enable a more accurate analysis to be carried out of the various careers of the former students. However, a survey of the distribution of former students in various degree courses in just three universities in Northern Nigeria, Ahmadu Bello University at Zaria (ABU), Bayero University, Kano (BUK) and Usman Danfodio University, Sakkwato (UDU), provides an indication of the discipline specialization of 308 of the former science school students. This distribution is shown in *Table 10*.

The expected year of graduation of the most recent student in that course is also given. This means, for instance, that by 1991 Kano State expects to have 22 medical doctors, since by then all of them will have graduated from their courses; 11 of the 22 potential doctors will graduate from ABU by 1989, the rest from BUK and UDU until 1991.

Similarly, by 1990, Kano State expects to have 87 scientists graduating in various disciplines ranging from biochemistry, microbiology, physics, to computer science and chemistry. Engineering, like medicine is also a discipline for which the policy initiators of the science schools expected a high turn-out. It is therefore significant to note that 40 engineers would be available to Kano State by 1988 from two of the universities in various sub-disciplines which included civil, mechanical, agricultural and chemical engineering.

Thus both the examination results of the students of the science schools and their placement in various universities studying science and technology disciplines, would seem to enable judgements to be made that the science schools project has met its main policy objectives for Kano State.

Table 10. Course distribution of science schools students in ABU, BUK AND UDU 1984-1986

Course	No	%	Graduation ABU	BUK	UDU
Science	87	28.2	1987	1989	1990
Engineering	40	12.9	1989	1988	--
Agriculture	39	12.6	1989	--	1990
Human med.	22	7.1	1989	1991	1991
Pharmacy	13	4.2	1988	--	--
Environmental Design	11	3.5	1988	--	--
Vet. medicine	6	1.9	1989	--	--
Prelim. science	87	28.2	--	--	--
Nonscience:					
Library science	1	0.3	--	--	--
Education	1	0.3	--	--	--
Business administration	1	0.3	--	--	--
Total	308	100.0	--	--	--

Source: Kano, Science and Technical Schools Board documents.

However, the picture is slightly altered if the placement of girls from science schools in tertiary institutions is taken into consideration. Even if many girl science students graduate from the girls' science school, there was no way of ensuring they could actually follow up both their educational and career aspirations in a traditional society such as Kano, as expected by the policy-makers. For as the Science Schools Board officials acknowledged,

> "...very few of them are now pursuing Science and science-related course in our institutions of higher learning." (Kano, Science and Technical Schools Board, 1985).

This statement is backed by an analysis of the distribution of 63 of the first students from the girls' science secondary school who graduated in 1985. This is indicated in *Table 11*.

Table 11. Occupational distribution of students from girls' science secondary school, Kano (1985) by field of study

	Number
Nursing	11
Laboratory technology	7
Pure science	6
Midwifery	3
Health assistants	2
Catering	2
Engineering	2
Islamic law	2
Teaching	3
Political science	1
Mass communications	1
Married	23
Total	63

Those listed as married in Table 11 are those who are not engaged as full time house-wives, while all the others were fully engaged in the various occupations listed (in addition, of course, to some of them being married). As *Table 11* indicates, nursing is the most popular occupational category as a field of further study by some of the students of the girls' science secondary schools -- thus conforming to the unwritten expectations of the special science school for girls -- which was to produce mainly nurses. Relatively few students from the graduating class of 1985 studied engineering subjects (2), while six studied science. Interestingly, quite a few decided to study for laboratory technology (seven); thus providing the medical profession with the greatest number of the students in all the occupational categories, since 23 of the students studied medically related disciplines. Surprisingly, none of the students decided to study medicine with a view to becoming medical doctors.

4.3 School to work

An extension of the second analytical focus -- manpower development -- deals with the extent to which the science schools project sets out to achieve a measure of the human resource development objectives it was aimed at achieving. This deals with not only the students' passage through universities and other institutions of higher education (mainly Polytechnics and Further Education Colleges), but also their insertion into the labour market to determine how many of them are serving the state, the federal government or engaged by private companies.

Because follow-up services of the graduating students from the science schools are quite poor, it is difficult to trace the placement of those who graduated from the universities and other higher institutions (from 1988) into the labour market. However, I was able to trace some 261 of the students by September 1990. A summary of the areas of specialization and places of work is given in *Table 12*.

Table 12. Summary of the distribution of a sample of the graduates of the Kano State science secondary schools in the Nigerian labour market, 1990

Field	State	Fed.	Priv.	N/A	Total
Engineering	35	30	7	12	84
Medical services	49	1	5	3	58
Architecture/building	33	2	1	9	45
Teaching	19	5	0	3	27
Agriculture	18	0	2	3	23
Banking	3	0	7	3	13
Others	3	6	2	0	11
Total	160	44	24	33	261

Source: Kano State Science Schools Old Boys Association Secretariat, 1990.

The total number of the personnel traced in the labour market is quite small compared to the over 4,000 that the science schools have produced over 10 years; nevertheless, if the trend indicated in Table 12 is an indication of things to come, it would seem that the graduates of the science schools might have started to justify the establishment of the schools.

Quite a few of the graduates were working for either private companies (PRIV) or the federal government (FED); but the majority were working for Kano State (STATE) Government. The state government actually encourages the diffusion of Kano State personnel into both the federal and private sector services, the argument being that although the science schools were primarily set up to solve the problems of Kano State, they are also a Nigerian enterprise, and their graduates should be working in all spheres of the Nigerian economy. Perhaps not surprisingly, this has led to the idea of the science secondary schools being copied in many other Nigerian States. Indeed, in a statement on 25 February 1991 in Kano State, the visiting Federal Minister of Education suggested that the Federal Government would pursue the possibility of setting up science secondary schools along the Kano models in every state of the federation.

However, the most important implication of the science secondary schools project is in employment prospects, and within the years specified, it would not be unusual if, with the output of science based graduates produced by the science schools, the schools enabled the production of highly qualified unemployed manpower. The next, concluding chapter of this monograph will discuss the implications of this issue along with the general directions of the entire project.

Chapter 5

Policy implications from the study of Kano State science secondary schools

From the summary account presented in the monograph, a number of conclusions can be drawn which have policy implications not only for the science schools as they are, but also for other communities with similar socio-political characteristics to Kano, and by extension, other states of Nigeria, where moves are being contemplated to maximize human resource development by the establishment of special science secondary schools.

5.1 Location and number of special science schools

It would appear that for facilities such as the science secondary schools to succeed, or achieve a reasonable justification based on their outcomes, the emphasis on establishment should be certain unit areas, especially in multi-ethnic metropolitan communities. This is because one of the factors attributed to the success of the science secondary schools in Kano was the *relative mono-cultural status* of Kano State -- a State with an estimated population in 1991 of 10 million people sharing the same religion (Islam), history and cultural background -- which makes it possible for policy decisions to be accepted on the basis of their merit, rather than whether they reflect sectional interests (see, for instance, the arguments about politics and professionalism in Nigerian education provided by Urwick, 1983).

Another factor was the *relatively smaller number of schools that started the project.* As an official of the Science Board who was involved in the planning stages of the science schools explained in retrospect:

> "I think four science schools will be enough for Kano for the next ten years. You see when you plan these things you have to plan it well. You have to put your investment in one or two. ... I am sure if we had started with four or six schools, the whole story would have been a failure today." (Interview 29 September 1986)

Thus, despite the success of the first two schools established in 1977, by 1991 only five science schools were in operation in Kano, three for boys, and two for girls. Other Nigerian States (especially in the North), impressed by the outcome of the Kano State science schools project, started similar projects with a massive number of such schools; ranging from six to twenty-two. Eventually, most of these states were forced to prune down the number of these capital-intensive schools to a much more manageable number in order to ensure effective monitoring as in Kano State.

5.2 Political and social stability

Again, for facilities such as the science schools to succeed, there must be *relative stability in the conception of the policy* as a whole. The serious problems that the Turkish experience of Science Lycees was facing in the late 1960s were to a very large extent caused by constant changes in the policy-makers who also changed the educational policies, regardless of their overall significance for human resource Development in the long run. On the other hand, one of the reasons for the success of the science schools in Kano State, Nigeria, is attributable to the fact that the schools were more or less left alone (or protected) in the turbulence of the Nigerian political structure. While there were many changes in policy-makers in the state, the main policy embodying the objectives of the science schools remained more or less immune to these changes.

And by the time attempts were made to mould the schools to serve the political interests of those then in power (especially during partisan politics), the schools had emerged from an embryonic uncertainty to fully-fledged suppliers of human resources. At that time it would have been unwise to consider deleting them from the educational landscape of Kano State.

Thus for facilities such as the science schools to be effective, they do need to stand on their own, as distinct from the larger budgetary headaches associated with a huge parent Ministry.

The separation of the science schools from the Ministry of Education in all respects (recruitment of teachers, selection of students, distribution of equipment and materials and capital expenditure) has helped tremendously in making the schools more effective. Failures and successes are not easily thus identified, and can inform decision-makers about the sustenance of such parastatals. The success of the Science Schools Board is a testimony that such independence is possible and desirable.

5.3 Purposes and outcomes

One of the most significant features of the initial 'Science Schools' Project' was that the mechanism by which the objectives of the policies were to be achieved had not been made integral to the main body of the policy itself. This has created a considerable amount of confusion regarding the actual objectives of educational policies in the minds of the implementors of the policies. Thus, providing a policy framework is not sufficient; there is a need to determine how objectives stated by education policies can be realistically attained within the framework of the policy as given.

Nowhere in the processes that led to the development of the science schools was the main purpose of increasing the scientific awareness of pupils at secondary school level, all too evident as the driving force to establish the science schools. And yet this is contrary to a main theme of teaching and learning science in any society. This is because the trend propagates the belief that increasing the quantity of students with scientific background will invariably increase the number of people able and willing to apply scientific knowledge and skills to the solution of social problems. Thirteen years after the project was started there is no evidence this can be so if the project continues along its present course.

So far the most explicit measure of the achievements of the science schools project that can be made in Kano is that more students from Kano are studying science and technology disciplines in higher institutions. Similar satisfaction with the products of the Turkish Science Lycee were also recorded in 1967 -- three years after the establishment of the Lycee. As quoted:

> "Of the Science Lycee's first graduating class of 100 students, 73 passed the entrance examinations at Middle East technical University. Among these 73, top scores in physics, chemistry, mathematics and engineering were Science Lycee graduates... About half of them still elected engineering, to be sure. But what warms my heart is that no more than half elected engineering, that only 10 elected medicine, and that 25 chose teaching and research, four physics, and four Mathematics." (Maybury 1975, p.144).

But are graduates from science schools actually miniature scientists or are they only good at regurgitating scientific facts and information which enabled them to pass their examinations and obtain spectacular results which were pleasing to policy-makers and politicians? The science schools project in Kano has no mechanism through which this very vital question can be answered, especially as it applies to those students who join the labour market immediately after leaving the schools.

To make any appreciable impression on the scientific awareness of the pupils requires more than a provision of excellent teaching and learning facilities. The main purpose of engaging in science teaching and learning at the secondary school level should be to awaken the intellectual curiosity of children and orient them to appreciating science as a guiding force in their personal lives and to use it as a powerful tool of social and personal advancement. The science schools project, unique as it undoubtedly emerged, does not provide for the full attainment of this objective -- either through adequate administrative provisions or teaching and assessment mechanisms.

Of course, further research needs to be carried out to determine the decisive factors in the outcomes of such projects: the provisions made, or other factors, in particular the personality factor of the students?

5.4 Gauging the transition from school to work

Another policy implication behind the establishment of the science schools relates to the extent to which the graduates of the science schools can be effectively integrated into the economic system. There is no doubt that science schools' graduates are needed in many areas, such as health, agriculture and engineering (although, as we have seen, Kano State Government emphasized health).

But equally many of them are produced in areas for which the Kano State economy does not provide an immediate means of employment. For instance, quite a few of the post-secondary graduates are pure scientists and others have backgrounds in chemical engineering, computer science, and other related sciences. There is insufficient evidence to show that they can be absorbed by the Kano State economy of the early 1990s. At most, those who graduate in pure science will become science teachers -- a task for which they are ill-equipped. What might derive from this is a 'brain drain' of graduates of the science schools to either federal government establishments, or other states with more flexible economic infra-structures. If this happens, it will defeat at least to a certain extent the initial purpose of the science schools project in enabling Kano State to use science as a powerful instrument of social and economic advancement. Massive investment in the further expansion of science schools could lead to the paradox of over-production and unemployment of science graduates (see, for instance, the argument forwarded in this direction by Irizarry, 1980).

So far no educational policy reflects its awareness of the possibility that eventually there would be an over-production of high school and university graduates for whom there would be no immediate employment because the economy has not kept pace with their production -- a situation created by lack of awareness of policy makers of the economic forces that determine the utilization of skilled manpower.

It is of course appreciated that the Science Board has no control whatsoever on what students eventually end up studying at higher institutions. But effective guidance while they are in the schools, in making the students aware of study and employment options, coupled with careful monitoring of their choices in consistence with Kano State's economic and social needs ought to be a strong feature of all the science schools, far beyond the nominal guidance provisions that presently exist in the schools.

This last implication highlights the need for a close correlation between policy development in education and economic development in the society, and the need for an effective linkage between the activities of the Science Board and other sectors of the Kano State economy. At the moment, there is no input from other service sectors of the bustling economy of Kano State (one of the most important commercial centres in Nigeria) into the science schools, e.g. through links between representatives of the industrial or agricultural sector of the economy and units in charge of the curricular or co-curricular activities of the science schools.

As a first step in redressing this potential problem, there is a need for an organization responsible for science education such as the Science and Technical Schools Board to be more definitive about the purposes and outcomes of science instruction in schools under its domain. This can best be done through a clear and specific science education policy that not only details the expectations of science instruction for students but also provides detailed pedagogic and other strategies of achieving these expectations.

These more specific and operational aims must be derived from a wider source than the membership of the Science Board, and should have inputs from various sources: a body representing the former graduates of the schools, principals of the schools, industry and community representatives and any other group of individuals the Board may co-opt for the purpose. Out of all these, a cluster of emphases can then be drawn up, and these should guide the formulation of a more effective science education policy, as well as its successful implementation in the science schools.

Conclusion

As sources of manpower production in science and technology, and as planning strategies in the effective utilization of resources for the provision of science instruction, the science secondary schools are desirable if they can be made more result-oriented to go beyond just quantity and include quality. The experience of the Kano State, Nigeria, science schools narrated in this monograph, I hope, provides an indication for future directions with regards to maximizing the efficiency of such planning provisions in secondary science education.

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The book

This volume explores the development and outcomes of special science secondary schools as a strategy for human resource development in Kano state, Nigeria. The science schools, introduced by the state government in 1977, were aimed primarily at enabling specially selected senior secondary school students (Grades 10-12) to be taught science subjects in a new and different environment from that of conventional secondary schools. These schools were seen as the main way that Nigeria will eventually have a large supply of highly qualified manpower in science and technology, believed necessary for modern social and economic development.

The study focuses on the institutional realities of the science schools and provides an insight into the mechanism of these as agencies of manpower development in science and technology disciplines.

The outcomes of the Kano State science schools as innovatory strategies in provisions for secondary science education clearly indicates that such strategies are desirable, particularly in the light of the large number of graduates such schools could produce over a period of over ten years. And if a proper institutional framework is provided for their operation, such educational facilities can certainly also help enhance the quality of science-trained human resources and be maximized for ultimate efficiency in the use of science education as an instrument of economic social development in any society.

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