INTERNATIONAL SCIENCE EDUCATION

John P. Smith, Section Editor

Two Decades of Science Education in Africa

M. B. OGUNNIYI
Department of Teacher Education, University of Tbadan, Nigeria

Introduction

The teaching of modern science in Africa began when western education was introduced into the continent during the last half of the nineteenth century. Science teaching in the primary school at that time consisted mainly of nature study, hygiene, and agriculture. At the secondary school level, physics, chemistry, biology, general science, agricultural science, and health science were taught. For the next century or so science was taught as a dogma rather than as systematic inquiry.

With the advent of political independence in the late 1950s and the early 1960s, most countries in Africa realized that the type of science being taught in the schools was not compatible with their aspirations. There was a wide gap between the needs of the society and the level of scientific and technological manpower available to meet those needs. There was a strong belief that the way to correct this state of affairs was to develop a sound science education program. The aim of this article is to provide a brief analysis of the nature of science teaching and curriculum development in science in Africa during the past two decades as well as suggest possible future directions.

Nature of Science Education in Africa

Before the late 1950s and the early 1960s, the science curriculum in most African states was in the form of the syllabuses of the different subjects set up primarily for examination purposes. The curriculum was left to grow by itself—a process akin to the evolutionary mechanism of natural selection. In terms of the curriculum, it was thought that obsolete or irrelevant materials would die a natural death while new ideas would gain prominence.

Science Education 70(2): 111–122 (1986)

CCC 0036-8326/86/020111-12$04.00

The end result of this false assumption was the cluttering of the curriculum with materials that presented an inadequate view of science.

Revolution in science teaching actually began in the West. The drifting about of science teaching in terms of objectives and practice after World War II began to take a new turn in the early 1950s. The factors responsible for this shift of emphasis are well documented in the literature. But even before the echoes of the revolution in science teaching reached the shores of Africa, several African leaders were already searching for ways and means by which science teaching could be made compatible with the postulates of their newly won independence. According to Chaytor (1980), several ministerial conferences, namely, Tananarive (1962), Addis Ababa (1961), and Lagos (1964), gradually evolved a pan-African policy on science education that placed a great premium on equipping each pupil with desirable scientific knowledge, skills, and attitudes.

During the ministerial conference in Lagos (1964) it was noted that African countries were handicapped by an absence of adequate national policies on science as well as bereft of any national machinery for coordinating and preparing such a policy. According to a UNESCO report (1974), the Yaounde symposium of 1967 showed some effort by several African countries at science planning, decision making, and coordination. Also, much had been done by then (in the spirit of the Lagos conference) toward preparing and implementing concrete national policies in science. By the late 1960s, many countries had begun to feel their way toward "a concerted science and technology policy".

Cessac (1963) contends that the need to produce the needed scientific and technological manpower as well as the need to expand the base for scientific literacy in the emergent countries of Africa prompted UNESCO's decision to organize a meeting of science education experts at Abidjan (Ivory Coast) in 1960. After that meeting Cessac, under the auspices of UNESCO, carried out a survey of secondary school science teaching in tropical Africa. The report showed a number of shortcomings, namely, (1) poorly equipped laboratories, (2) shortage of funds, (3) inadequate ancillary facilities and basic services, and (4) lack of well-trained laboratory assistants. Although the survey did not cover the supply of qualified science teachers, research reports from various countries at that time showed that qualified science teachers were in short supply.

Since Cessac's (1963) report, research efforts regarding the status of science teaching have been somehow localized to individual countries. For example, Weaver (1964) carried out a survey of science teachings in the Western Region of Nigeria and concluded that the type of science being taught could not prepare students adequately for future careers in science. Kalamananthan (1970) came to a similar conclusion about the status of school science in the six northern states of Nigeria. Ten years after Weaver's study, Asenuga (1974) examined the conditions of science teaching in the western region of Nigeria and reached the conclusion that "our laboratories are full of mess." Similar unsatisfactory situations were reported for other states: Lagos State (Teibo, 1975), Kwara State (Ogunniyi, 1977), Oyo State (Orisaseiyi, 1977), etc. Indge (1976) reported that science teaching in Kenya was of a poor quality. Similar reports were made at the Liverhume interuniversity conferences held between 1958 and 1968 in East Africa (Gilbert & Lovegrove, 1972). At the Inaugural Conference of Science Educators in Africa [now Forum of African Science Educators (FASE)] held in Lagos in 1980, most of the participants complained about the poor state of science teaching in their countries. At the first international FASE Conference (1982) the poor state of science teaching in Africa was a topic of major concern.

A recent survey carried out under the auspices of Science Education Programme for Africa (SEPA) and covering most countries in tropical Africa was that of Yoloye and Bajah in 1981. The report, titled *A Report of Twenty Years of Science Education in Africa*, examined different aspects of science teaching and concluded that, despite the significant efforts made to improve the status of science teaching, most African countries had not attained the target set at the Addis Ababa Conference in 1961.

As of this writing, the International Association for the Evaluation of Educational Achievement (IEA) was evaluating the status of science teaching in the secondary schools of a number of African countries. It will be a miracle if the survey comes up with a different picture than has been known already. This prediction is not hard to come by when certain factors are considered, namely, (1) the rapid increase in student population owing to the implementation of universal primary and secondary education in several countries; (2) the shortage of funds and consequently of laboratory facilities—a situation caused by the current worldwide economic recession; (3) the shortage of well-trained science teachers and laboratory assistants; (4) the rapid rate in which teachers are transferred; (5) the negative influence of external examinations; (6) the rapidly changing sociopolitical conditions and attendant contradictory educational policies, etc. All these factors will definitely affect the IEA's study or any similar studies.

Curriculum Innovations in Africa

According to Yoloye and Bajah (1981) the process of curriculum development is perhaps the most remarkable change that has taken place in the educational system of many African countries since independence. In 1960 the conference on Science in the Development of New States held in Rehovolt, Israel brought about the idea of exploring and applying modern curriculum development techniques in the educational system in Africa. A conference held in the following year at the Massachusetts Institute of Technology (MIT), Endicott House (U.S.A.), laid the foundation of curriculum development in science and mathematics in Africa. Several regional and interregional conferences were held to prepare the ground for a true revolutionary science teaching in Africa. The Rome conference of 1964 helped to motivate the enthusiasm of many African science educators for curriculum development. In 1965, a conference held in Kano (Nigeria) under the auspices of Educational Services Incorporated (later Educational Development Center, Newton, Massachusetts) brought together the cream of science educators, scientists, and psychologists from all over Africa to discuss the issue of educating the African child in science. A body known as the African Primary Science Programme (APSP), or later the Science Education Programme for Africa (SEPA), evolved from this conference. The APSP was indeed the watershed of curriculum development efforts in Africa.

Several organizations have given support for the development of new science curricula in Africa. Over the years UNESCO has provided financial as well as moral assistance for curriculum development efforts. For example, in 1975 UNESCO sponsored a workshop on the teaching of Integrated Science in African secondary schools. In the same year, the International Institute for Education Planning (IIEP) of UNESCO organized a workshop on curriculum development and evaluation in science and other school subjects. One important outcome of that workshop was the creation of the African Curriculum Organization (ACO), an intergovernmental educational body concerned primarily with promoting

and monitoring curriculum innovations all over Africa. UNESCO also involved science teachers and educators in the rewriting and the revision of its source books on science teaching (Nwana, 1980). Other bodies involved with curriculum development in Africa include the British Council, the International Council of Associations for Science Education (ICASE), World Confederation of Organizations of the Teaching Profession (WCOTP), the Commonwealth Fund for Technical Cooperation (CFTC), International Council of Scientific Unions (ICSU), United States International Development Agency (USAID), United Nations Children's Fund (UNICEF), the World Bank, the Swedish International Development Agency (SIDA), the Ford Foundation, the Rockefeller Foundation, etc.

The aid provided ranged from financial assistance, supply of laboratory equipment, textbooks, films, slides, etc., to the supply of teachers and the training of curriculum specialists and teachers. Projects sponsored specifically by UNESCO/UNICEF include the Namutamba Project in Uganda, the Midwest (Bendel) State Primary Science in Nigeria, the Primary Science Project for Northern States of Nigeria, the Bunumbu Project in Sierra Leone, etc.

A significant aspect of curriculum development in Africa is the creation of several curriculum development centers or units. These centers or units have produced a variety of science and mathematics curricula, textbooks, audio-visual aids, etc. Other fringe benefits of the curriculum movement include the evolution of various national and international organizations. In addition to the African Curriculum Organization (ACO) mentioned above are such bodies as the African Association for the Advancement of Science and Technology (AAAST), the West African Association of Science Associations (WASA), the West African Association of Science Teachers (WAAST), the recently formed Forum of African Science Educators (FASE), in addition to various national and international professional associations. Also, various countries have adopted a variety of techniques to improve their level of science education.

The curriculum development centers mentioned above use modern curriculum development techniques and are responsible for the preparation of student textbooks, teachers' guides, and audio-visual materials that are first tried in a number of schools, evaluated, and revised before final production and dissemination to the schools. According to Yoloye & Bajah (1981) there are at least three benefits of the new movements:

1. The content and the materials have become more relevant to the society for which they are intended.
2. It has promoted experimentation in curriculum development.
3. External examining bodies have begun to take into cognizance not only the syllabuses developed by their own subject panels but also the new curricula emerging from the curriculum development centers.

Other related benefits of the movement perhaps are

1. The development of a crop of trained personnel in curriculum development process.
2. The inclusion of teachers (though few in number) in the process of curriculum development, thus acquainting them with the philosophies of the programs.
3. The accumulation of useful data of overall regional efforts in curriculum development in science education.
4. The realization that curriculum development forms an integral part of educational planning and development policies.

5. The awareness that curriculum development should not be an incidental affair but a process requiring constant innovation and management.

As indicated earlier, curriculum development efforts in the West have contributed significantly to the development and growth of science education programs all over Africa. The basic themes of these programmes show this quite clearly (see Table I). According to Atchia (1980) the themes for the Integrated Science Curricula are basically three: (1) fundamental or conceptual, (2) environmental, and (3) applied. Chaytor (1980) asserts

TABLE I
Some African Curriculum Projects, Principles, and Materials

Curriculum	General Principles*	Materials
PRIMARY (5+ to 13 years)		
African Primary Science Programme (APSP) - now Science Education Programme for Africa (SEPA).	Science is an important aspect of society and should be for all. Science is an inquiry.	Pupil textbooks. Laboratory Manuals/Workbooks.
Midwest Primary Science (Nigeria).	Major theories of intellectual development (e.g. Piaget) and learning e.g. Gagne, Ausubel and Bruner.	Teacher's Guide.
Nigerian Primary School Science Primary Science Project for: a. Northern States b. Kenya c. Tanzania d. Sierra Leone e. Gambea	Three approaches, viz: topics or concepts; environment; application or technology. Pupil-centred curriculum	Supplementary learning materials viz: films, slides, transparencies, kits, etc.
SECONDARY (11+ to 16+ years)		
Arab League Countries Integrated Science (ALESCO).	Science is an inquiry	Student textbooks. Laboratory Manual/ Workbooks.
Integrated Science: a. Ghana b. Botswana c. Lesotho d. Swazeland e. Mauritius f. Nigeria Nigerian Secondary School Science Project (NSSSP) Biology, Chemistry, Physics.	Science is a system of idea about the world and hence for all humanity. Centred around 1) fundamental topics or concepts, viz: air, water, electricity, pressure, living things, etc.; b) the environment, viz: pollution, natural resources, energy, conservation of wild life, soils etc. c) technology, viz: food production, housing, clothing, safety, prevention of diseases etc. Emphasize the role of science in the Society. Emphasis on practical work and projects. Student-centred and disciplined centred curricula.	Teacher's Guide. Supplementary learning materials viz: films, slides, kits, etc. Use of locally improvised apparatus.

*These general principles are by no means mutually exclusive or exhaustive (after Balogun, 1975).

that the revolution in science teaching in Africa has seen a shift in emphasis from rote learning to inquiry learning stressing problem-solving skills and the habit of making rational choices.

Overall Trends in African Science Education

An examination of Table I shows a shift of emphasis from rote learning to inquiry activities and from teacher-centered approaches to student/discipline centered approaches. Before the early 1960s the science curriculum was geared toward the fulfillment of overseas examination requirements, namely the Cambridge School Certificate Examinations, the London General Certificate in Education for the Anglo–phone countries, and the Baccalauréat Parts I and II for the Franco–phone countries.

Science education objectives commonly found in practically all independent African States starting from the early 1960s include (1) the development of the spirit of inquiry; (2) the understanding of valid views of the nature of science, i.e., its tentative and revisionary character; (3) the teaching of problem-solving using scientific techniques, namely, observation, measurement, formulating or testing hypotheses, experimentation, drawing valid conclusions, etc.; (4) impartation of scientific literacy; (5) development of manipulative skills and scientific attitudes; (6) understanding the interaction between science and the society; (7) the transformation of the environment; (8) the production of individuals who are capable of participating in socially useful and productive activities; (9) the production of citizens who are better consumers of scientific products; (10) accelerating the development of potential scientific and technological manpower; etc.

A clear pattern for science project development at the lower secondary school level has been the integration of subjects from the fields of science and technology. Haggis (1980) has advanced three reasons for this: (1) the interdisciplinary nature of science, (2) the multifaceted nature of education, and (3) socio-political concern. Other reasons can be added to this: the fact that science at the primary school was taught as a unity rather than as different subjects, and the fact that this stage marks the end of the study of science for a large proportion of students. Whether or not the content of the Integrated Science course depicts the unity of science adequately has been a matter of great concern. It is quite evident, however, and except in isolated cases that most countries have replaced the general science course with one form of Integrated science or another.

At the upper secondary school level there has been a gradual shift in emphasis from the mere acquisition of scientific facts and principles to inquiry and problem-solving activities. The main constraint, however, has been the strong influence of external examination on the whole educational system.

As a result of the expansion of the educational system in the 1960s there has been a relatively sharp increase in student population. This has led to a number of problems such as the inadequacy of laboratory facilities, the poor teaching and supervision of science, and the massive movement of dropouts from rural to urban centers in search of jobs. Various governments have tackled this problem by establishing crash programs for the training of science teachers, setting up a number of centres for making low-cost equipment, as well as repairing those not readily made, e.g., microscopes, chemical balances, and electronic equipment. Also, the governments of the various countries have sought ways of solving the problem of unemployment by establishing one program or another. Accord-

ing to Yoloye and Bajah (1981) various slogans were were used to describe this effort. For example in Uganda science education was geared toward "job-makers" rather than "job-seekers," in Tanzania the slogan was "education for self-reliance," in other countries the emphasis was "the dignity of labor," "rural transformation," "rural integration,"etc. To achieve this objective the pupils were engaged in feasible occupations in their rural environment, for example: farming, poultry, piggery, and other forms of animal husbandry. A good example of this is the Namutamba Science Project in Uganda. Also, various countries have adopted a variety of techniques to achieve the target of building specialized institutions for science, technology, and science education.

In addition to the efforts mentioned above, many universities, polytechnics, technical colleges, and colleges of education instituted admission policies that favored the admission of more students in the area of science, technology, agriculture, and science education. But, unfortunately, the quota allocated could hardly be filled. Some countries, e.g., Kenya and Tanzania, extended their quota system to the secondary school level. Other countries, e.g., Nigeria and Ghana, paid inducement allowances to science and mathematics teachers. In Kenya a science teacher was given a salary scale higher than his art teacher counterpart. Virtually all the countries provided generous scholarships for science courses. Worthy of note were scholarships provided by other countries or bodies outside the continent, namely, Israel, the U.S.S.R., the Commonwealth, the British Council, Ford Foundation, Rockefeller Foundation, etc. The United States of America, Canada, Britain, Germany (East and West), and many countries from the Eastern Block either provided financial aid and/or voluntary service corps, most of whom were science teachers. The significant role played by the U.S. Peace Corps, the Canadian CUSO and the British VSO especially in the area of secondary school science teaching the 1960s has been a notable landmark in many African countries. Unfortunately the political wind that blew over the continent in the late 1960s and the world economic recession that began in the early 1970s brought this noble effort to a premature termination. Many African states provided opportunities for the expansion of science education. Also, as the industries increased many of the industries provided scholarships for students while others set up programs for technical training, thus increasing the overall output of skilled scientific and technological manpower.

In the 1970s a great emphasis was placed on the teaching of science right from the primary school to the university. The worldwide Integrated Science movement of the 1960s had a great impact on science education at the lower secondary school level. Within the past two decades the West African Examination Council and the East African Examination Council (now in separate countries) have completely taken over the conduct of examinations from the Cambridge Overseas Syndicate. The increasing concern for rural integration that began in the mid-sixties intensified in the 1970s (Yoloye & Bajah, 1981). Even now, greater emphasis is being placed on rural transformation through the teaching of agricultural science and the inclusion of technological and sociological topics in the primary and the lower secondary school science curricula. The theme of the first international FASE conference in Harare (1982) was: "How Relevant Is Science Education to the [Dropout]." There was a consensus at the Conference that the acquisition of scientific and technological skills by pupils was germane to viable rural transformation.

But despite the efforts made so far, no single country has reached the target set at the Addis Ababa Conference in 1961. The projection at that conference was that by 1980 the

requirements for true scientific and technological manpower would have been achieved. The obstacles that have prevented the attainment of this objective are many. In the following section I shall highlight some of these and suggest the direction to which science education in Africa should go in the 1980s and beyond.

Problems of Science Education in Africa

The experience of the past two decades has brought about a strong awareness all over Africa that the present form of science being taught in the schools does not prepare pupils to function well in a society undergoing transition from a rural economy to a modern economy. This state of affairs was graphically enunciated in the FASE Conference Resolutions (1982):

> We are aware of the goal of education to produce human beings who are self-reliant. . .. We are aware of the failure in many ways of our current science education programmes to prepare the [dropout], be it at the secondary school level or at the primary school level, for useful living. . .. We observe that most African governments have in no way positively supported and sustained action programmes to make science education functional with a view to replacing or complementing academic preparation. . .. We recognize that our curricula are rather deficient of technology, and in particular appropriate technology, for the transformation of rural life. We recognize that our examination system is inadequate, to say the least, and yet has its stranglehold on the educational system. We note with regret that governments often-times institute far-reaching changes in curricula or educational systems at relatively short notice and sometimes without cognizance of professional opinions. . ..

The list of problems enumerated above is by no means exhaustive. The problems range from lack of adequate textbooks, reading difficulty of the textbooks, lack of funds to purchase equipment, overcrowded classroom/laboratories/time-table, lack of cooperation by school administrators, the pressure of external certificate examinations, etc., to lack of proper monitoring and feedback mechanisms, poor preparation of teachers who teach the new programs, lack of motivation among teachers, the rapid rate in which teachers are transferred from one school to another or out of the profession, the use of archaic teaching methods, poor implementation procedures, overwhelming number of activities demanded by the new curricula, shortage of qualified science teachers, lack of clear-cut goals, scanty research reports on the performance of the programs, prevalence of superstitious beliefs, and the general lack of a reinforcing home environment, etc.

An important item that is missing in the development of science education in Africa has been the conspicious absence of an active involvement of the scientific community. There are enough well-informed opinions and research evidence to show that the type of science being taught in our institutions provides at best ready-made knowledge isolated from our cultural background (Weaver, 1964; Ogunyemi, 1969; Abubakar, 1970; Bajah, 1975; Cole, 1975; Ogunniyi, 1977; 1979; 1983). And yet the professional scientists pay very little attention to this problem. The consequence of this is the production of the reversal of Montaigne's classic phrase—a "well-packed mind" rather than a "well-formed mind." All over Africa there is a great drive to import western science and technology like one purchases merchandise from the market. The zealots of "technological transfer,"

as Alatas (1977) has eloquently argued, are not aware that without a truly creative intellectual spirit that gave rise to modern science and technology, such an enterprise will at best be piecemeal, imitative, and expensive. It is also clear that the proponents of technological transfer, oblivious to sociopolitical forces in the world, are shooting for the stars. Are they not aware of the fundamental role of science education in scientific and technological manpower development?

Poor planning and implementation as well as the lack of clear-cut policies have been the most agonizing problems bedeviling the realization of science education objectives in Africa. It is not the provision of the learning facilities for science or even the wise use of them that is important but the sociopolitical context in which they are used. In Africa today science has to fight for survival. The scientist, the intellectuals, and the science teachers are not accorded a high social status. The embryonic development of science education will show in every cell of our development plans that in most African states today there are many underdeveloped decision makers and advisers on science. All over the continent one sees all sorts of slip-shod and haphazard efforts at planning and implementation—crash programs for the training of science teachers and laboratory technicians, crash erection of classrooms and laboratories, crash implementation of a new policy on education, and so forth. Whether or not positive results will emerge from such activities is totally irrelevant to many a government. After all, there are "intellectuals" who will prophesy an inevitable success, adequate planning or not.

It is not that positive steps toward the development of science and technology have not been taken; it is that the steps taken have consistently lacked a scientific approach. Various hesitant and ambiguous attempts at planning and implementation of sound science education programs have been made, but these have practically always been improvised and rarely well implemented.

The Future Direction of Science Education in Africa

There is no simple solution to the multifarious problems facing science education in Africa. Fortunately, people of all shades of opinion are aware of the magnitude of the problem. The increasing emphasis on rural integration could serve as a useful catalyst to concerted efforts at planning and implementation of virile science education programs all over the continent. To be relevant now and in the future, the science curricula should reflect both contemporary and emerging needs of the diverse cultures. The development of various science curricula (rather than just one) with different emphasis is a step in the right direction.

There is a great need for relevance. Although by nature science is universal, the needs of the different cultures and economies are not the same. Certainly, topics that relate to mechanized farming, control of malaria and many tropical diseases, ecological balance, provision of good drinkable water, production of food, development of good roads, drought, small agro-based industries, etc., are more relevant to the African settting than such topics as computers in the schools, computer-assisted learning, laser beams, radio activity and many other topics that have featured in the science curricula of industrial societies. Most of the textbooks, especially at the upper secondary school level, will have to be rewritten to reflect the need of the students and the society as a whole.

The new emphasis that presents science as an inquiry will not be realized unless the examination system allows for this. The newly implemented continuous assessment program being adopted by many countries should reduce the negative influence of external examinations. Again, this depends on how well implemented is the continuous assessment program. The need to prepare science teachers and laboratory assistants to implement the new programs cannot be negotiated. The new science curricula demand teachers who are capable of using instructional procedures that are supportive of the new emphasis. As Akintola (1971) puts it

> Our educational needs have grown beyond the competence and know-how of most of our teachers. It is therefore essential that organized teacher in-service education become an inseparable aspect of curriculum development activities. For success in this very crucial endeavour, teachers need help which must be provided at instructional, state and national levels in an organized and coordinated manner.

The present situation in which African scientists are completely isolated from curriculum development efforts is unhealthy not only for their respective countries but also for the scientists themselves. Curriculum development in science needs their input as well as the input of science teachers.

The esoteric programs presently available in many of the science departments (particularly, mathematics and physics) of our universities should be replaced with some realistic ones to attract the average students to major in science subjects in order to be able to teach them afterwards. This is not a call to lowering the standard of our education but to develop programs suitable for the majority of the students. After all, many who could not cope with the science courses at the university turn out to become secondary school science teachers—i.e., teachers with little science and with little or no teacher training.

The development and implementation of a worthwhile science curriculum is a costly business. Although many African countries are spending a vast amount (ranging between 5 and 40 percent or more of their annual budget) on education, much of this spending does not yield the desired result. This, as discussed earlier, is more a problem of poor planning and implementation procedures than of investment. Broad surveys about the status of science education programs in Africa are urgently needed. The data obtained will be very useful in the planning and the implementation of new science curricula. Also urgent is the need to organize meaningful in-service and on-service training programs for science teachers. Unless this is done, success will continue to elude us.

Lastly, science educators must learn the acrobatics of the politics of influencing government policies on what they are doing or intend to do. Support by government, industry, or the society at large for any enterprise, be it the much needed mobile laboratories, science and mathematics education resource centers, or any other venture, does not come readily. It comes with a lot of consultation, pressure, persuasion, and propaganda.

Conclusion

In this paper I have highlighted different aspects of science education in Africa in the past two decades or so. The areas of interest have been a cursory review of the history, problems, and prospects of science education in the context of a continent undergoing sociopolitical upheavals as well as transition from an agrarian to an industrial economy.

References

Abubakar, I. (1970). The role of science and technology in national development. *West African Journal of Education, XIV*, 30–36.

Akintola, J. M. (1971). In-service training. Report of the National Workshop on Primary Education. Nigeria Educational Research Council, II.

Alatas, S. H. (1977). *Intellectuals in developing countries.* London: Frank Cass & Co. Ltd.

Alonge, E. I. (Ed.) (1980). Proceedings of the Inaugural Conference—All African Association of Science Teachers, Lagos.

Asenuga, J. J. (1974). Our laboratories are full of mess. *Journal of Science Teachers' Association of Nigeria,* 61–62.

Atchia, M. (1980). Tendencies in the choice for integrated science courses. In E. I. Alonge (Ed.), Proceedings of the Inaugural Conference—All African Association of Science Teachers, Lagos.

Bajah, S. T. (1975). Preparation of the secondary school teacher of the physical sciences for the African environment. *West African Journal of Education, XIX*, 85–86.

Balogun, T. A. (1975). Some current science curriculum developments: Levels and global rationale. *Unpublished mimeograph,* University of Ibadan (Nigeria).

Cessac, J. (1963). *Science Teaching in the Secondary Schools of Tropical Africa.* Paris: Firm—Didot, Mesilsur—L'Estree.

Chaytor, D. E. B. (1980). Shaping science education in the eighties. In E. I. Alonge (Ed.), Proceedings of the Inaugural Conference—All African Association of Science Teachers, Lagos.

Cole, M. A. (1975). Science teaching and secondary curriculum development in a supposedly non-scientific culture. *West African Journal of Education, XXIX*, 313–332.

Fafunwa, A. B. (1967). *New perspective in African Education.* Macmillan Educational Ltd..

Forum of Africa Science Educators (FASE) (1982). Report of first international FASE conference. Harare: August–September, 1982. Report: International Council of Associations of Science Education (ICASE).

Gilbert, P. G. S., & Lovegrove, M. N. (1972). *Science Education in Africa.* London: Heinemann Educational Books Ltd.

Haggis, S. (1980). Integrated science world-wide. In E. I. Alonge (Ed.), Proceedings of the Inaugural Conference—All African Association of Science Teachers, Lagos.

Indge, W. J. E. (1976). The potential for local manufacture of school science equipment and related problems. Report of a Commonwealth Regional Seminar Workshop, Nassau, Bahamas, Nov. 1976, 26–30.

Kalamananthan, K. (1970). An investigation into problems involved in science teaching in secondary schools in the six northern states of Nigeria. *Journal of Science Teachers Association of Nigeria, 10*(3), 60–62.

Nwana, O. C. (1980). Cooperation among science teachers' associations in Africa. In E. I. Alonge (Ed.), Proceedings of the Inaugural Conference—All African Association of Science Teachers, Lagos.

Ogunniyi, M. B. (1977). Status of practical work in ten selected secondary schools of Kwara State. *Journal of Science Teachers' Association of Nigeria, 16*(1), 36–46.

Ogunniyi, M. B. (1979). Meanings associated with science concepts and generalizations by scientists and students. *African Journal of Educational Research, 2*(2), 175–183.

Ogunniyi, M. B. (1983). An analysis of laboratory activities in selected Nigerian secondary schools. *European Journal of Science Education, 5*(2), 195–201.

Ogunyemi, E. L. (1969). Science curriculum design in a developing country. *West African Journal of Education, XII*, 104–144.

Orisaseiyi, S. (1977). A critical look at the attitude of secondary school students to physics. *Journal of Science Teachers' Association of Nigeria, 16*(1), 49–55.

UNESCO (1974). *Science and Technology in African Development: Science Policy Studies and Documents*. Paris, UNESCO Press.

Stone, R. H. (1960). *A Survey of Science Teaching in Nigerian Grammar Schools, Occasional Publication No. 1.*, Nigeria, Institute of Education, University of Ibadan.

Teibo, B. O. (1975). An investigation into the problems encountered by Nigerian Secondary School pupils in learning chemistry. *Journal of Science Teachers' Association of Nigeria, 13*(3), 71–76.

Weaver, E. K. (1964). Science education in Nigeria. *Science Education, 48*(4), 351–361.

Yoloye, E. A., & Bajah, S. T. (1981). *Science Education for Africa, Vol. 1: A Report of Twenty Years of Science Education in Africa*, SEPA.

Accepted for publication 28 December 1984