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MANAGEMENT AND INTEGRATION OF SCIENCE RESOURCES IN GHANA'S EDUCATIONAL REFORM PROGRAMME

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ABSTRACT

This paper attempts first to review the state of affairs in educational institutions with reference to science education vis-à-vis the expected standards. Secondly, the effort of Government, through the Ministry of Education and the Ghana Education Service, to provide pre-university institutions with adequate resources for science teaching, especially from 1986 to 1995, are discussed. Thirdly, the identified problems which may have eluded the attention of planners and administrators in charge of the educational reforms are mentioned and analyzed. Finally, probable solutions and suggestions are made to assist the authorities concerned to revisit the blue-print of the Educational Reforms Programme and make the necessary modifications.

Introduction

The need for a change in the teaching and learning of science in Ghana has long been identified and efforts have been put in place to address this issue as outlined in the aims and objectives of the Educational Reform Programme. However, the rate at which the change is taking place and the adequacy of efforts made leave much to be desired. Investigations conducted so far indicate that though some attempts have been made to assist students learn science by doing, with guidance and instruction from trained and competent staff, and in an environment that encourages teaching and learning, a lot more needs to be done. Institutions in desperate need are those found in the rural areas as well as the newly established community-based senior secondary schools. Many schools cannot teach meaningful science except to teach students to do rote learning to enable them pass examinations. This has come about due to the inadequate supply of both human and material resources. An efficient and versatile human resource is a central key to the development of science education in the educational reform programme. The environment and infrastructure including workshops and laboratories provide an exciting and very important source of enhancement in science teaching and learning. However, teachers and educators have often neglected the environment as an unique resource available for effective use. Science teaching will definitely be better done if the issue of inadequate supply of science equipment and materials is also tackled with zeal.

The Personnel Factor

It is generally conceded that the success of any human endeavour is closely related to the quality of the personnel who perform tasks necessary for the achievement of purpose as well as to conditions that affect their physical and mental well-being. This assumption is as applicable to school as it is to any organized human effort. The extent to which public education succeeds in delivering services with an effective use of scarce resources (inputs) will depend largely on the quality of the personnel engaged in the educational process and on the effectiveness with which they discharge individual and group responsibilities.

The environment and space are important. A well designed science education programme is essential, but leadership is vital. Money, equipment and materials are significant, but the most crucial single factor in the science education process is the yet unmotivated science resource personnel charged with the task of effecting desirable changes in children. Science personnel within the context of this paper refers to the classroom science teacher and school laboratory technician; science teachers and laboratory technicians at the resource centres; the scientific community (GSA, CSIR, GAST); stakeholders / beneficiaries (NGOs, GES, VALCO, UNILEVER, parents, students, etc.), and the West African Examination Council staff.

This section will attempt to address the following :

a) The adequacy and calibre of science teachers before and during the reforms at the various levels of pre-university education.

b) Steps being taken to improve the existing situation.

c) Problems and recommendations.

Before the Reforms

Science teacher education developed from the training of teachers to teach Nature Study and Hygiene. A one-year rural science programme was later mounted at Bagabaga Training College, Tamale, to train Certificate 'A' post middle and secondary to handle Science at the Primary and then Middle schools. The elementary school science syllabus at that time became the pivot of the science teacher education programme in training colleges. In 1973, a two-year science specialist programme was run in selected colleges throughout the country for a period of four years and this gave way to the three-year post-secondary science programme. Thus, in March 1975, the Agbenyaga Committee was appointed to review the entire teacher education programme. It recommended the establishment of a new teacher training course to be called "The three-year Post-Secondary Course" to replace the then two-year Post-Secondary course. Through this programme, the three-year "quasi-science specialist" replaced the two-year science specialist course as well as the two-year post-secondary science programme. In January 1981, GAST Teacher Training Panel with support from NTTC was to diagnose the problems of science teacher education in Ghana. This sparked off a chain reaction in science teacher education in the country.

Thus before 1987, the calibre of teachers qualified to teach science at the basic school level included

i. the Certificate A post-middle and secondary,

ii. the two -year specialist science teacher, and

iii. the one-year rural science teacher. This requirement assumed that the science teacher had a professional training as a teacher as well as being grounded in the techniques and methods employed in the teaching of science, organizing and improvisation of basic science apparatus, programmed instruction, teaching mechanisms and many other new concepts coming in as a result of the dynamic nature of science. The number of qualified teachers were woefully inadequate to meet the school requirements. Hence pupil teachers with middle school certificates and GCE 'O' and 'A' levels were employed to teach and these taught science as well. Most of these teachers had very weak science backgrounds and so perpetuated the cycle of weak science backgrounds for the pupils they taught.

At the second cycle level - Secondary and Teacher Training levels - the basic qualification of the science teacher as spelt out by GES included at least the possession of a specialist certificate, a diploma certificate in science education and a bachelor's or master's degree in science from a recognized university, preferably with an education background. However, arising from the inadequacy of professional competent teachers, non-professional graduates from the University of

Ghana, Kwame Nkrumah University of Science and Technology, 'A' level holders, and in some cases, post secondary teachers found their way into the science classroom.

With laboratory technicians, they are required by the GES to possess a certificate or diploma in Laboratory Technicians course. But like the teachers in the teaching profession, their number is very low. Hence non-qualified persons such as 'O' level and Middle School leavers have found their way into the system as laboratory assistants or attendants. Before 1992, the statistics available at the Lab-Tech office at UCC showed that only 222 laboratory technicians were trained and turned out to GES. According to Association of Science Educators *et. al.* (1970), the establishment of a school of a population of 1200 students needs five laboratory technicians. Unconfirmed reports indicate that only about 60 % of laboratory technicians trained by UCC are still with the GES. The rest are with industries where conditions of service are better for them.

Before and in 1987, the GES, GAST and other stakeholders such as the Overseas Development Agency (ODA), pooled their resources together to prepare the teachers in the system for a take-off of the programme. In September 1987, all middle and continuation schools were converted to Junior Secondary Schools. Between 1988 and 1990, GAST organized courses, workshops and conferences to discuss the syllabi of the various science subjects (Biology, Physics, Chemistry and Core Science) at the SSS level and made recommendations to the GES and MOE. GAST, supported by the scientific community and other stake holders and beneficiaries, also started with the preparation of GAST subject textbooks to guide its members during the implementation process of the reforms. GAST in 1990 also reviewed the existing teacher training science syllabi. It also organized refresher courses at its AGM to further update their knowledge. As a result of these seminars, a source book for college science tutors was drafted and tried out in the colleges.

With financial assistance from ODA, JSSTEP, courses were equally mounted by the Institute of Education, UCC. Science Resources Preparation Centres were developed purposely to help science teachers prepare and become conversant with the variety of instructional materials that they would be using. In 1990, the GES / MOE organised orientation courses for science teachers in secondary schools at four centres in Cape Coast. At these centres or courses, teachers were taken through the syllabi and also given political education on the rationale for the reforms.

During the Reforms

The first batch of the JSS students came out in 1990 and in the 1990/91 academic year the Senior Secondary School (SSS) programme was started. The calibre of teachers at the primary level had not changed since the reforms had not touched this level yet. In July 1991, primary six teachers were called to the respective district capitals and given orientation courses in the teaching of the Primary Six science syllabi for a period of two weeks. Because of the shortness of the duration, these orientation courses hardly made any meaningful impact. Hence one might say, the calibre of teachers was about the same as before the reforms. Since 1991, little effort has been made to give in-depth refresher courses to the primary school teacher on the teaching of science. However, trends in the percentage of trained teachers since 1987 in the primary schools has shown an appreciable increase,

Table 1
Trends in the Percentage of trained teachers in the Public Basic Education Level 1986 - 1994

YEAR	PRIMARY	JSS
1986/87	55.8	64.6
1987/88	57.9	68.0
1988/89	60.1	71.8
1989/90	66.4	64.9
1990/91	66.1	75.9
1991/92	73.8	72.1
1992/93	72.4	76.3
1993/94	73.3	75.6
1994/95	81.6	78.0

Source : Ministry of Education, Accra, 1997

Class 1 - 5 teachers were also called at zonal levels and given training in the teaching of science by resource personnel organized from the District Education offices.

pre-supposing that trained teachers have equally increased (See Table 1 column 2). But the percentage increase of 25.8 % between 1986 and 1995 is however small when weighed against an increase in the number of primary schools by 40 % within the same period. This might suggest that there was no substantial improvement in science teaching at the primary school level.

Since the initial orientation of the JSS science teachers in 1987 not much effort has been made to raise the quality of JSS science teachers. Tufuor (1989) in a research conducted showed that out of 27 teachers interviewed in the Cape Coast District, 2 were diplomates, 13 were post-secondary trained teachers and 12 were 'A' level holders. All the post-secondary trained teachers had weak science backgrounds and two had no science passes at all. If this is the gloomy picture in the Cape Coast district, which is the cradle of western education in Ghana, then God help Adukrom JSS in the Eastern Region and Kpasinkpe JSS in the Northern Region.

These findings are supported by Dapilla (1996) in a research conducted to find out the "state of science teaching in the JSS in the Jirapa-Lambusie District of the Upper West Region of Ghana". He found out that only 20 % of the 30 JSS science teachers were actually qualified to teach science because they specialized as 3-year post-secondary science teachers. 80% of the teachers also expressed the difficulty of teaching science at the JSS level and these were those who were 3-year post-secondary teachers who specialized in other subjects. He therefore, concluded that the teacher background to teach science in the JSS in the Jirapa-Lambusie district was unsuitable.

A cursory look at the statistics in Table 1 column 2 shows that adequacy and quality have not improved over the years. The change in the trends of the percentage of trained teachers between 1986 and 1995 is only 13.4 %. This does not augur well for primary school teachers and re-inforces the findings by Tufuor (1989) and Dapilla (1996). Thus, the basic education system still harbours unqualified science teachers.

As stated earlier, the SSS programme took off in January 1991, when the first batch of JSS students came out in July, 1990. In October 1990, in-service courses were organized in Cape Coast to give orientation to the science teachers towards the implementation of the programme. In 1991, a similar course was organized at Winneba for those who were not in the system in 1990. The calibre and adequacy of science teachers in the SSS remained as before the implementation of the programme due to the expansion of intake and also the policy requirement that all SSS students read core science. The periods (teaching load) of the science teachers increased. However, there was no appreciable corresponding increase in teachers. An examination of the trends in the numbers of teachers in the SSS in Table 2 column 4 from 1992 to 19995 shows a negligible increase. This is so because the trends in the number of teachers in the Polytechnics, Diploma Awarding Institutions, and Universities (Table 2, columns 7,8 and 9) did not see any marked increase; hence they could not increase their products either. The Diploma awarding institutions and the Universities rather saw a drastic drop in the trends in the number of trained teachers (Table 2, columns 8 and 9).

diplomates and professional graduate teachers. However the training colleges lacked qualified teachers (e.g. for the 1996/97 academic year, Bimbilla E.P. Training College had no science teacher, and Tamale Training College had only one).

Steps Being Taken to Improve the Existing Situation

1. There have been sweeping changes in the Teacher Training science education programme since 1990. The post-middle Teacher Training programme was phased out and

Table 2
Trends in the Number of Teachers in the Public System by Level 1986 - 1994

YEAR INST.	PRIMARY TTC	JSS	SSS	TECH. INST	TCC	POLY TECH.	DIP INST.	UNIV.
"86/87	64,357	31,633	7,741	737	968	387	180	-
"87/88	63,367	32,612	7,813	760	964	368	192	1,462
'88/89	62,670	34,584	8,528	792	1,001	386	184	1,163
'89/90	62,859	35,262	8,087	824	981	393	185	1,361
'90/91	62,823	30,708	9,195	882	952	406	192	1,115
'91/92	66,378	33,395	10,016	869	950	410	207	1,273
'92/93	61,724	32,896	11,876	863	967	411	41	1,379
'93/94	62,314	36,110	11,846	855	1,004	419	50	1,349
'94/95	60,947	35,622	11,401	862	1,028	487	52	1,400

Source : Ministry of Education, Accra, 1997

The quality of teachers at the training colleges improved. Specialists and graduate non-professionals were in 1991 removed from the system to make way for

replaced by the three-year Post-Secondary science teacher programme. In this reform, two science teacher programmes are run by two categories of training colleges. Group 1 colleges are designated Science Training colleges. The student teachers here specialize in teaching science and science-related subjects such as Agricultural Science and Technical Drawings. Group 2 colleges are designated Arts and Business Training colleges. They run a basic science programme for two years to enable them teach science at the primary school. They are examined in their Part I examinations as an external paper. This affects their certification, hence students are usually serious. But the quality and adequacy of qualified science teachers is still below average at the basic level (Tufuor, 1989; Dapilla, 1996).

2. The establishment of Regional Colleges of Sciences has been proposed. It is hoped that very soon these will take off. The three-year post-secondary science programme is to be upgraded to the status of Diploma programmes.

3. Opportunity has been offered to Diplomate science teachers to pursue a 2-year post-diploma programme to upgrade themselves to degree status at UCC and UCEW. This will improve the calibre of personnel at the SSS and TTC levels.

4. Co-ordinators of Science Resource Centres have been given orientation in the management of science resources centres in the country. This includes training in the performance of all the experiments in the science syllabi using the materials and equipment provided at the centres. Laboratory technicians have also gone through similar orientations.

Problems Encountered by Human Resources in the Reform

1. It has been realized that the gifted and above average students are unattracted towards the teaching profession but are more inclined towards Medicine, Engineering and Administration, etc. The reason is that the teaching profession does not offer any incentives. It is, indeed, an irony that whereas the nation is trying to set up industrial plants in accordance with the latest technology in science education, we are content to follow out-moded and stereotyped practices.

2. It has also been noted that since the initial euphoria of orientations, nothing has been done to give the science teacher in-service training.

3. Boakye (1986), cited by Tufuor (1989) reported that the national organizer of the reform programme identified among other things the inadequacy of staff, i.e. science teachers and laboratory technicians. No meaningful records/statistics of science teachers nation-wide have been made available to advise science teacher producer agencies on the needs of the country.

4. The esoteric programmes presently available in the faculties of our universities do not meet the calibre and requirements of the reforms. Also, the science education programme as run by the Department of Science Education at UCC is far removed from the aims and objectives of the reforms, especially at the second cycle level. If really the graduates are to handle the secondary school science programmes as spelt out in the aims of the B.ED Science Education Programme, then the teachers should be given training in the syllabi of the SSS course content. This includes both theory and practical requirement.

Suggestions

1. All science teachers should be given up-dated in-service training as done for the coordinators of the science resource centres. Alienating the classroom science from the science resource centres is like trying to separate school science into "practical" and"theory" lessons and it is the same as trying to perpetuate a dichotomy which is an antithesis of true science teaching.

2. Personnel development should be pursued by GES/MOE so as to attract, retain, and improve the quality and quantity of science personnel needed to implement the programme and achieve results. This could be achieved through :

   i. Improving the performance of personnel in their present positions (in-service training).

   ii. Developing key skills of selected personnel so as to fill anticipated vacancies (staff development).

   iii. Promoting the self-development of all personnel in order to enhance their influence as individuals and to facilitate need satisfaction (staff development).

If these are done, then the best brains can be equally attracted and retained in the science education system. Through personnel development, science personnel can experience personal growth, professional growth, upward mobility, motivation and job security.

3. Statistics should be compiled on the trends in the number and quality of science teachers and laboratory technicians at the pre-university level. This will enable GES/MOE to produce answers to the following questions :

   i How many science teachers and laboratory technicians are there within the system ?

   ii How well have they been trained and how well have they achieved the goals of the science education programme ?

   iii How long will it take to achieve the goals with the quality and quantity of present personnel ?

   iv How much money will it cost to train a quantity of science personnel ?

4. The science programme run in the universities should be restructured to address the aims and objectives of the reforms. The programmes should direct their attention on "hands-on" and "minds-on" objectives. This will produce the science and technology minded citizens who are needed in the contemporary world.

5. It is worthwhile for the GES/MOE to draw a comprehensive and consistent science education centred policy document to ever influence issues centred around science personnel. This therefore calls for the establishment of a Directorate for Science education at the GES.

Instructional Equipment and Materials - an Underlying Factor for Successful Educational Reforms

Learning by doing is one of the cardinal principles of teaching science. Experimentation has put many theories on a sound footing and has also resulted in the rejection of many. History reveals that many beliefs and superstitions were thrashed out from the minds of people as a result of experimentation. The achievements of modern science are mainly due to the application of the experimental method. Practical work must therefore be made a prominent feature in any science course (Sharma, 1995).

If science is poorly taught and badly learnt, it is little more than burdening the mind with dead information, and it could degenerate into a new superstition. For some time now, many science teachers have had no option but to resort to the lecture method partly due to the demands of the type of external examinations students are prepared for, or to the inadequacy or lack of science materials and apparatus, such as microscopes, telescopes, burettes, glassware, library books, science museum materials, standard textbooks, workbooks, teachers' manuals, chemicals, etc.

Ghana's sweeping educational reforms theoretically lays greater emphasis on hands-on education, in addition to minds-on and values-on education. Considering the objectives of the reforms, one would expect the Government to supply adequate and appropriate science equipment and materials to all levels of education. Unfortunately, this expectation has not been met.

A survey of science equipment and materials at various levels of the formal education system precipitated the following findings :

i Kindergarten through Primary Six : Supply of basic science apparatus and materials like test tubes, beakers, etc. are still being considered. The environment is therefore being prepared to serve as the resource for basic science teaching to a large extent.

ii Junior Secondary School level : In 1988/89 academic year, each school was supplied with an average of two boxes of assorted science materials and equipment including General Science text books. The supply enables the science teacher to hold demonstration lessons for five groups of at least eight students each. Some of the items in the science kit are as follows : sieves, measuring cylinders, rubber bungs, funnels, hand lenses, magnets, glass tubes, wire gauze and chemicals like Benedict's solution, iodine, potassium permanganate, charcoal powder etc.

iii Senior Secondary School level : The Government already has a scheme for supplying schools with science equipment and materials though inadequate. The Government must be given credit therefore for establishing and equipping Science Resource Centres throughout the country. An amount of £ 20 million has been committed by Government for the project. The establishment of the Science Resource Centres is a laudable idea because students who hitherto had no access to some equipment and materials can now have hands-on experience at these centres.

Each Science Resource centre has equipment and materials adequate for practical lessons. The Biology department, for example, has altogether 745 pieces of equipment and the co-ordinators of the centres confirm the adequacy of the supplied equipment and materials. There are also at least two computers supplied to each department to aid the teaching-learning process. In addition, the possibility of connecting the centres to the Internet is being considered. This will expose students to international/scientific websites, software and programmes and help them rise up to the challenges of the scientific advancement of our modern world.

The project is more or less a national one and the Government is ensuring that Philip Harris Company Ltd., which is responsible for furnishing the centres with equipment and materials, hands over to the District Assemblies the responsibility of replenishing the centres. The main objectives for establishing the science centres have been found to be the following :

i Serve as teaching centres to supplement existing facilities in secondary schools and give ample opportunities for practical work using modern facilities and techniques, including the use of computers.

ii Provide tuition for students in schools without well-equipped laboratories.

iii Serve as centres for running in-service training programmes for teachers of science at JSS, SSS, and Technical education levels.

iv Serve as venues for students to engage in the development of their science projects.

v Provide facilities for running Science, Technology and Mathematics Education (STME) clinics for girls.

The benefits of the project when completed are expected to be substantial. These include an improvement in the teaching and learning of science, increased enrolment of science students at the secondary and tertiary levels and a general increase in enthusiasm for the learning of science.

Problems Affecting Science Teaching and Learning due to the Inadequate Supply of Science Equipment and Materials

1. The delayed supply of basic materials and equipment to supplement resources from the natural environment and the lack of use, or inadequate use, of the environment as a resource by some teachers constitute a problem that needs serious attention.

   Most theorists in social psychology believe that many of our attitudes are formed during childhood and therefore emphasise the role of basic learning principles at that stage. The development of positive attitudes towards science must therefore be inculcated into the child from kindergarten through primary school. Once the psychomotor skills are developed the interest generated for science will serve as the momentum for any further scientific adventure beyond the primary stage. If a child's natural curiosity and desire for manipulation of objects is not nurtured at the tender age, there is no guarantee that when the child encounters the SSS science equipment at the Science Resource Centres, he would be attracted to science. The use of learning aids helps the intellectual development of the child and his scientific process skills. This implies that the earlier the child is exposed to learning aids the better. Another advantage in the early use of science equipment and materials is the minimization of the likely formation of misconceptions in the child's mind.

2. The establishment of the Science Resource Centres is laudable but there are related problems that need urgent attention :

a. The science centres are meant for practical work to supplement science teaching and not to replace teaching in satellite schools. However, due to inadequate publicity and education, the impression created is that teachers in satellite schools have two options, that is either to conduct lessons at the centres with the assistance of trained staff or just observe as the centre staff conduct the practical lessons.

b. The cost of transporting students to and from the Science Resource Centres, excluding the maintenance of the vehicle, is quite substantial. Centre co-ordinators complain that funds needed for the running of the buses are not readily available.

c. The objectives of the project include developing computer literacy among teachers, students and other citizens of the nation. However, the inadequate number of computers makes the objective highly unachievable as projected. Each centre has at most two computers in each laboratory meant to serve groups of students, some numbering up to 40.

d. According to the official criteria for the selection of the centres, the 110 centres should be so located such that all 452 Senior Secondary schools in Ghana would have access to the centres. For cost effectiveness, each centre is expected to serve about five schools. So far, with an average of three schools being tried out, there are disturbing problems with the time-tabling. Currently, some schools have four or more streams of science students in SSS 3 alone. If four or five schools are assigned to one centre, only SSS 3 students may have access to the centre. In addition to this problem, centre teachers and technicians will be overworked, if they have to work all day long from Monday to Friday in order to accommodate all schools.

e. If the Science Resource Centres, as at now, cannot adequately cater for all elective science students, one may ask the following question : "How do core science students, as well as students from teacher training colleges and technical institutes benefit from the centres ?"

Suggestions

1. The economic status of the nation may not be capable of supporting the importation of all the required equipment for all schools. In the light of this, it is strongly suggested that Science Improvisation Centres (SICs) be established at vantage points or as annexes to the Science Resources Centres (SRCs).The GES in conjunction with GAST should mount programmes to give science teachers training in how to improvise materials to meet the requirements of the science syllabi. The products from the Improvisation Centres could also be used to feed rural schools where necessary. The Government must, as an incentive, create special awards on regional and national basis for the best improvised science teaching aid of the year. The criteria for the award may include the least costly item yet most affective in terms of accuracy, durability and easiness in manipulation.

2 Teachers accompanying students to the centres must have no lesson in their own schools for the day they would be at the centres. Thus, the time-table of the schools concerned must be adjusted so that students do not miss lessons.

3 The number of schools per centre should be maintained at three as much as possible. If the number is increased

to five, there may be the need to have SS1, SS2 and SS3 students visiting the centres on rotational basis just once a month. How that will be done and the ease with which it will be done is obviously going to pose more problems. This points to the fact that the supply of equipment, apparatus, etc. to all schools or institutions must not stop with the establishment of the Science Resource Centres. Some activity-based science teaching must go on in the individual educational institutions.

4. The Science Resource Centre Co-ordinators should be encouraged to plan activities for, and also visit, training colleges, technical institutes etc. to assist with science teaching, instruction and experimentations (practicals).

5 Well-equipped libraries should be set up to help students do some personal research or seek more scientific information.

6. Science museums should also be set up to serve as model for emulation for successive generation of students.

7. Science teachers should be encouraged to write suitable textbooks related to children's experience and the environment.

8. Considering the present state of affairs, drivers of the Science Resource Centres' vehicles must be motivated just as the teachers and technicians. This will make all staff concerned conscientious enough to make it possible for the project to take off at least as the identified problems are solved with the desired swiftness. Monetary incentives will not be out of place for them.

9. Considering the financial burden on Government, all beneficiaries of the educational system should be encouraged to assist materially and financially. These beneficiaries include industries, private business concerns, non-governmental organizations and banks.

Environment and Space

The picture of the environment as a resource base for science teaching is reflected by these two objectives of Primary Science :

1. To introduce the pupil to the world of science by exploration and experimentation according to his interest.

2. To develop his ability to observe things around him more closely so that he can perceive relationships among objects and phenomena.

These objectives can be re-stated in operational terms in the following example. In their environment pupils will see animals, and several observations could be made. They could make notes of their observations on feeding, mating habits, breeding, fighting, note where they rest, how many young ones at a time, what the young look like, how they feed or are fed as well as what types of food they take in comparison with that of the parents etc. The list could go on.

The above underscores the importance of the part that the environment (i.e. school and community resources) can play in developing scientific attitudes in the pupils which will lead them to become scientists in the long run.

School, Building and Ground Resources

The nature of the curriculum and the energy of the teacher are the major considerations or factors in determining the extent to which resources outside the classroom/ laboratory are used for science. The attitude of the administrator/ headmaster is also important. However, certain aspects of the location and nature of the school plant and grounds make it easy or difficult for the teacher to extend his teaching beyond his classroom/ laboratory. Where those concerned with planning are aware of many possibilities for extending science teaching, much can be done to make it possible for teachers to use extra classroom resources.

There are many resources which the science teacher can utilize outside the classroom, but which are within the school compound. The school library for instance, provides obvious service which cares for the needs of the science department along with those of all other groups in the school.

In addition to service facilities, certain aspects of the school building and its equipment can become the basis for science teaching. The audio-visual equipment, the dark-room for photography etc. are examples of the many resources.

Other science facilities may be incorporated into the school plant. An aquarium/pond for ecological studies, rabbitories, a weather cock, a rain gauge, etc. are a few of the facilities that could be incorporated to enhance science teaching/learning.

Community Resources

In science, as in all school subjects, the community can become the classroom, i.e. the community becomes an extension of the classroom/laboratory. The science teacher is particularly fortunate in that so many of the community's resources relate directly to his field of study. In Biology, for instance, one thinks immediately of the zoo, parks, farms, the local hospital, sewage disposal plant, water systems, factories producing food and a lot more others. Natural resources which should be utilized are rivers, streams, swamps, ponds, forests and savannah areas. An aid to the effective use of these resources could be the preparation of a filing system in which each resource is listed by name; location when it is opened, the person to contact for visits and other pertinent information regarding it.

Factories that make chemicals, or products involving chemical processes, are effective aids to classroom instructions in chemistry. Industries that produce petroleum products, glass, paints, plastics, synthetic rubber, metals and alloys, and many other such materials can be visited by the chemistry students. Direct experience is essential to effective learning and fortunate indeed is the school located in a community that has variety of industrial establishments.

Much demonstration materials and raw materials for making equipment are available in the community. Scrap materials can usually be obtained locally at low or no cost at all. Samples of raw materials and industrial products serve to relate life of the community and the work of the school. With planning, the study for any of the sciences can become, in fact, a school-community activity. A very important resource in the community is the local residents with specialized abilities or backgrounds (e.g. physicians, dentists, nurses, engineers, technicians, etc.). With the increasing emphasis on individual guidance for students, many specialists can make lasting contributions to the education of the youth by talking to them about the opportunities in the professions and the qualifications necessary for pursuing them.

Hence, it is evident that the community is not so remote as it may seem. The school building and grounds are rich resources for physics, biology, chemistry as well as elementary science experiences, and as stated already, can become and should be an extension of the classroom/laboratory. What then can be done to realize the achievement of the two stated objectives, for there is no gainsaying the fact that field experiences provide first-hand experiences which are more lasting and worthwhile than all the classroom lectures ? What can government do for teachers to achieve this realisation i.e. in terms of encouragement (motivation), in-service training/workshops; and provision of finance to carry out some of the field trips etc. ? What can the community do and should do ? and what should be the teacher's role in this aspect using environment as a science resource base ?

The Science Teacher's Role

It is quite evident that very few science teachers make use of the environment. No doubt there are a lot of constraints, but every science teacher, no matter at what level, should make use of the environment and its resources. As an adage goes "one direct experience in the environment is worth a thousand pictures or explanations". Another re-echoes that "experience is the best teacher." The science teacher must remember that the environment is an extension of his laboratory in that,

- every classroom has its potential extension into the community in search of people, places and events that constitute community resources.
- such resources begin in and around the school building itself.
- education is not static, but is affected by many social forces. Therefore, a static blue print for the use of the community resources would have little value. Community resources are related to the needs and goals of the groups involved. The science teacher must therefore make the maximum use of the environment which constitutes the community resources by :

i exploring and exploiting the limitless teaching/learning materials that abound in it ;

ii giving the students/pupils first hand experiences by undertaking field trips and visits to places of scientific interests, which are related to the children's field of study in science;

iii bringing the community into the classroom by way of organizing lectures/talks related to science and inviting science personnel in the community to take part ;

iv organizing science fairs/ exhibitions which will draw the whole community into the school. Such fairs need not be organized using very sophisticated science equipment. The use of scrap and other simple materials for the fair would be a very good beginning. Students and pupils come to exchange ideas, parents see at first hand the efforts the school is making to bring science to the doorsteps of the community through their wards a simple praise from a parent of science personnel at such gatherings of a student's project, could lead to a scientific care. An appeal for science materials at such gatherings could yield tremendous responses in kind and in cash.

In all, the science teacher must realize that his teaching should be active and dynamic, in keeping with active children and a dynamic universe and hence develop a competency in the utilization of the environment to enhance his teaching.

The Community and the School

At the inception of the Junior/Senior Secondary School Programmes, community participation/ involvement was assigned a very high place. It has been observed that initially, community participation was very high but interests in the schools seem to be waning, at least in some aspects. For instance, most personnel in the community who were invited to schools to give talks/lessons, expected some kind of financial remuneration at the end of it all. However when this was not forthcoming, interests waned. In the light of this, the community's participation needs to be revisited. The community needs to be sensitized to the fact that the education of their wards is much their problem as it is the government's and teachers'. They should therefore participate without expecting any compensations from the schools and should readily avail the school of any material resources that will enhance the teaching/ learning processes especially in science. It is however heartening to note that in some instances community participation is very high and has often come to the rescue of distressed schools. The PTAs and Old Boys'/Old Girls' Associations are notable community resources.

The Government could allocate funds for the science teachers to explore and exploit the environment. Government could provide means for short/long trips to places that are of significance to the teaching/learning of science; and provide finances to purchase other materials from the environment to make teaching aids. Financing field work has not seen much encouragement and much needs to be done.

From the foregoing, it might be concluded that the fore-mentioned two objectives of using the environment for science teaching have not been achieved. Teachers find it difficult to provide adequate experiences in the field as outlined in these objectives due to ignorance, laziness, but above all due to lack of finances to undertake field trips.

Space for Science Teaching

Rooms used for science teaching have many common qualities regardless of the level or the field of science. Space requirements, illumination, and heating systems as well as attractiveness are some common qualities. Here however, the discussion will centre mainly on space needed for effective science teaching. Areas to be discussed include : area requirements per student, working space for science teachers, space for storage of apparatus and supplies (equipment), the situation as it pertains in our institutions of learning and its effects on learning and finally suggestions as to how this situation could be rectified.

Area Requirement Per Student

The teaching of science, as contained in the Educational Reforms of 1987, requires a larger area for each student than was provided for in the earlier science learning situations. The bases for this increased area are :

1. The nature of learning activities in science has been broadened to include a greater range of activities than in the past. Within this increased scope, there are various activities which in themselves require considerable freedom of movement on the part of the student.

2. There is now greater emphasis on small working groups and individual work, each of these procedures requires more space than formal classroom.

3. Science teaching now involves a greater wealth of learning materials than has been true in the past. There is a greatly extended array of apparatus, models, charts, diagrams, projected materials, computers (as at the various Science Resource Centres), greater amounts of glassware etc. all of which require larger areas for use; and

4. Lastly, the Educational Reforms have witnessed so far greatly increased numbers of pupils/ students at all levels in our institutions, and this by itself requires an appraisal of existing room space for learning in general and science teaching/ learning in particular

In the past, determination of needed floor area of science rooms have generally been based upon a minimum of two square metres per student. Experience indicates, however, that rigid adherence to an area-per-student formula alone with little or no thought for room arrangement results in cramped and unused areas. Effective science teaching requires a minimum per-student area of about 4 square metres. This calculation does not include such accessory space as storage room, preparation room, dark rooms, etc.

Storage of Apparatus and Supplies

Separate storage rooms for scientific apparatus and supplies are desirable in all schools. Often such rooms are used also for preparing for demonstrations and laboratory work, and repair and adjustment of apparatus. At the JSS/Primary levels, a science corner is often good enough for children's collections but room for storage of equipment and materials is still necessary.

Facilities for Demonstrations

Successful demonstrations require a satisfactory teacher's demonstration desk with necessary facilities, no matter the level. There must also be a minimum of demonstration equipment, which is in general, relatively large and simple. The demonstration desk should be high enough for students to see the demonstrated materials easily from their seats.

Room for the Science Teacher

A science teacher regularly engages in a number of activities for which space should be provided : keeping records, making plans, preparing demonstrations, repairing and creating equipment for student experimentation, conferring with students etc. as well as attending to his own professional growth through reading and other activities. There should thus be sufficient room provided as a preparation centre for the teacher. There should also be sufficient room for the teacher's desk to be somewhat separated from the desks of the students/pupils.

In our primary and JSS working space for the pupils is so small that it might be said to be non-existent. Pupils are crowded into rooms originally meant for only 46 pupils. In most cases, the rooms contain as many as double the required figure. These rooms were meant for general instruction in all fields of study endeavour and not specially or specifically designed for science teaching. At these levels, the emphasis should be on child-centred activities, where the child takes responsibility for his studies, and is given a wide range of choices in his science learning. The child needs to be mobile, but in these crowded rooms he has no chances to satisfy his burning curiosity to know more about himself and his environment. The teacher's table - that is if he has one - is so much surrounded by other pupils' tables and chairs that movement during any lesson is greatly reduced. How he teaches science is best left to him and anybody who cares to guess.

There are the lucky ones - those who happen to be housed, even though in most cases, these "houses" are more of a death-trap than a "house" where formal education should be executed. The not -so-lucky pupils are those who find themselves sheltering under the shades of provident trees and those who lie prostrate on their bellies and look up at the teacher as he delivers his "lectures".

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Under the conditions that are being described, how can a science teacher effectively teach science ? Truly, it might be said science must not necessarily be learnt in the classroom, but learning both in and out of the classroom, especially in the classroom, has its psychological advantage.

It is also worthwhile to note that the scanty science materials that the Government sacrifices so much "scarce foreign exchange" to acquire for these schools, in many cases, never find daylight, nor reach the science teacher (if there is one) since they are always locked away in the headteacher's office and in the boxes in which they arrived; and at times left to decay or waste away, since there is no space to display them.

The question is "Is the Government aware of these situations"? This can be answered in the affirmative since they have policy implementors who keep them informed of what is going on in the classrooms. If this is so, is the Government just paying lip-service to teaching the child science to be an all round person, and providing the much needed manpower in science, which is very vital to the development of our dear nation ? If it is not just lip-service the Government is paying to science (and we are all inclined to think Government is very serious about the success of the Educational Reforms, especially in the field of science), then there is the need to revisit and appraise the infrastructure situation as it exists particularly in the rural areas since WAEC does not discriminate between the lucky and less fortunate schools when questions are set in the final examinations.

The situation, as far as working space and storage facilities in the SSS is concerned is much better. As has been pointed out, for students to effectively carry our science practical work, be it project work, practical lessons, group discussions etc., a lot of space is needed. This is so because of the very nature of science. The existing laboratories in the very lucky SSSs were originally designed for 30 students. Occasionally, teachers have had to put the side benches/ equipment cupboards to "good use" due to increased numbers. However, with the take-off of the SSS programme, the number in the classrooms have more than doubled, thereby overtaking the space available for students and teachers alike to work in. In many cases, students' science working space has now been reduced to something less than one square metre.

Yet, as has been pointed out, the new science programme stresses a hands-on teaching, a method of teaching which requires the teacher abandoning the traditional method of transmitting knowledge where students act as sponges, just soaking up what the teacher passes on to effectively teach science ? Truly, it might be said science must not necessarily be learnt in the classroom, but learning both in and out of the classroom, especially in the classroom, has its psychological advantage.

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Yet, as has been pointed out, the new science programme stresses a hands-on teaching, a method of teaching which requires the teacher abandoning the traditional method of transmitting knowledge where students act as sponges, just soaking up what the teacher passes on to them. The generative learning model, which requires the students to generate knowledge from their own activities, underscores the teaching-learning situation in science in the Educational Reforms. Most science experiments need large space to be carried out. Sometimes, there are so many students clustered around the teacher's table, for want of space, that even demonstration exercises become a big problem to the science teacher.

In many of the new SSSs, the science equipment that has come in cannot be stored adequately; in most cases they take up precious working space in rooms designated science rooms.

It is assumed that science in the secondary school must serve two purposes at the same time (i.e. for the development of young people in the scientific aspects of their lives and for the growth of science itself) and that the schools should provide for both. Opportunities for this dual growth are possible within the usual course offerings and that as the science curricula of the future are planned, those courses that are based upon broad and developing curricula, or on the application of science, or on intensive or extensive work in a particular aspect of science, merit careful attention. The simple question that may however be asked is "Was the science programme as outlined in the Educational Reform given the careful attention in the area of working space, or was it left to take care of itself"?

If it was left to take care of itself, then it is high time the Government got informed that a lot more space is needed for effective science teaching/ learning.

At the Primary /JSS level, the pavilions being erected are praiseworthy, but they are woefully inadequate. Community participation is stressed, but communities are so poor they cannot afford to be active part-takers of providing meaningful education to their wards.

In other communities, PTAs are supplementing the efforts of Government. With the Government's introduction of FCUBE (i.e. Free, Compulsory, Universal, Basic Education) in the 1997/98 academic year, the pupil population has expectedly increased dramatically. Is room space also going to be increased dramatically ? Government should re-visit this situation as space is very vital for the teaching /learning process, particularly for science.

The second cycle institutions also need a lot of room space, for it is this stage that the to-be scientists emerge. They therefore need the chance to explore and experiment. Government is already providing science resource centres, but the computers and other materials have gone to occupy very precious spaces in these laboratories. More space is needed and in this area it has been noted that various PTAs are working gallantly to help out, but again the Government must sit down and re-address the problems of space in these institutions. The idea of de-boardenization is to allow many more students to benefit, not to de-congest these congested institutions.

The situation in the tertiary institutions is worse. Practical work in science has become a great problem since these laboratories were made to cater for about 50 students at a time. Now we have 200 to 300 students in them at a time. There is the need for stake-holders to come to the aid of the Government. There is also the much talked about cost-sharing in the universities which it is hoped will enable the government to direct much attention to providing more space for learning. All these are praise-worthy but it is still the duty of Government to provide the needed space for scientific work.

In summary, it is apparent that the agencies of Government, when they planned the implementation of the Educational Reforms of 1987, did not take into consideration the large numbers that would result, especially in a rapidly growing population as ours, and as such have literally been taken unaware as far as provision of space is concerned. They need to work and work fast to alleviate the appalling situation that seems not too far away if more space in our institutions of learning is not provided. May be re-visiting the shift system in all its forms could be a short term measure; but there is the need to stress that teachers should be adequately motivated financially to make the educational reforms a success.

Conclusion

An attempt has been made by this paper thus far to show the state of resources for the teaching and learning of science in this country and the implications of the presence or lack of these resources for an effective science education programme. Suggestions have also been made on how to moderate the overall negative influences of the lack of resources.

Also from the foregoing, it is evident that although Government has been making spirited efforts to develop science education in this country, the overall result has been less satisfactory. Therefore much remains to be done if the country is to develop scientifically and technologically.

It is the fervent hope that the suggestions made so far would be critically examined and given the highest consideration by the appropriate authorities who are in charge of science education policy formulation and implementation.

All said and done, it must be emphasized that the most important of the science resources - the science teacher - without whom it will be difficult for the objectives of any science education programme to be achieved, should be highly motivated with incentives of diverse kinds.

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