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THE SCIENCE EDUCATOR AND STUDENT ACHIEVEMENT IN NIGERIAN ENVIRONMENT: CONCERNS AND TASKS AHEAD

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Abstract

The paper examines science quality for all students with the intention of presenting a vision of a scientifically literate populace. It identified that science education in general education in schools does not seem to help students achieve scientific and technological literacy or feel confident either in applying their knowledge or dealing with societal problems. It recommended that if the standards are going to become a reality in Nigeria, a shift will be necessary from what has traditionally been an experience in science education classroom to the inquiry techniques for quality teaching/learning. It is the contention of the researcher that the inquiry approach would enhance students' achievement in science classroom, hence the thrust of this paper.

1. Introduction

The National Research Council (NRC) in 1966, published the National Science Education Standards (NSES) with the intention of presenting 'a vision of a scientifically literate populace'. The NRC created the standards around a central theme 'science standards for all students'. This theme emphasizes the importance of inquiring in the science process, allowing students to describe objects and events, ask questions, construct explanations, and test those explanations, against current scientific knowledge, and communicate their ideas to others'. In teaching science with an inquiry emphasis, the assumptions of the diverse populace are considered, and critical and logical thinking skills are fostered.

The training of skill manpower in science for the different aspects of national development is considered a priority action area. This ought to receive special attention in the light of local and national needs whereby the individual can organize human concepts and attitudes, classify experience and communicate with others. Thus, science education must be a part of general curricula and be integrated with all education. A scientifically and technological literate society should be the prime aim of the final product.

In many countries particularly in developing countries, the science education in general education in schools does not seem to help students achieve scientific and technological literacy or feel confident either in applying their knowledge or dealing with societal problems.

If the standards are going to become a reality in the classrooms in Nigeria, a shift will be necessary from what has traditionally been the experiences in science education classroom to describe what students typically experience in traditional classrooms as follows(Brooks and Brooks,1999):-

a) curriculum is presented part to whole, with emphasis on basic skills
b) strict adherence to fixed curriculum is highly valued
c) curricular activities rely heavily on textbooks and workbooks
d) students are viewed as ‘blank states’ onto which information is etched by the teacher
e) teachers generally behave in a didactic manner disseminating information to students learning
f) assessment of students learning is viewed as separate from teaching and occurs almost entirely through testing
g) students primarily work alone.

However, several factors necessitate change in the traditional classroom teaching of science education as follows:-

1.1 Knowledge and population explosion

Knowledge explosion is a major factor that is influencing new trends in the teaching learning process. New facts are being discovered everyday as a result of research and development activities. It is a common knowledge that new facts are emerging at a rate at which it is impossible for a single individual, no matter how versatile to keep pace with. For instance, in the field of chemistry, Dalton’s atomi9c theory has had to modify with the advent of sophisticated instruments that made it possible for scientists to discover that the atom is no longer the smallest indivisible particle, but is made up of electrons, neutrons, protons etc. Thus, with the invention of sophisticated equipment, new discoveries are made everyday, especially in the field of science. The implication of this is that no single teacher can be expected to be a prime source of knowledge in any field. In fact, it is this fact that has led to the atomization of field of knowledge into areas of specialization.

Knowledge explosion in accompanied by yet another set of problem, namely, the problem of increase student enrolment and decrease in the number of trained teachers to cope with this increased enrolment. The implication of the above is that rather than wait until it can recruit qualified teachers to cope with this population explosion, a school system can select appropriate instructional materials produced by experts and make such materials available to its learners.

1.2 The changing nature of the learner

The nature of the learner has also helped to necessitate a change in the traditional role of teachers. Both the traditional and the nontraditional students in Nigeria want to be actively involved in the teaching learning process. A traditional student is a full time student whose major preoccupation is to attend lectures in order to achieve objectives predetermined by a school. The purpose of registering in a school for a traditional student is to obtain diploma, which can be used for employment. A nontraditional student on the other hand, may be a full time worker such as a supervisor in an industry or a cultural officer in a ministry or even a disabled person. He or she attends school or a training workshop at his or her spare time or under the auspices of his/her employers as a means of improving his/her skills and competence. It was realized that, both the traditional and the nontraditional students constitute a heterogeneous group.

A realization of this heterogeneity has led to a shift in the traditional 'lockstep' approach to teaching in which every member of a class is taught the same lesson at the same time adopting the same strategy and in the same place. Science educators are therefore compelled by this learner heterogeneity to provide alternative units of instruction and alternative strategies to enable the science students to attain educational objectives at their own rate.

1.3 The emergence of new resources for the teaching –learning process

New resources such as films, filmstrips, slide transparencies, radio, television etc are now available for large and small group teaching as well as for individualized instruction. Science teachers in different schools in the developed countries of the world are trying out new concepts such as team teaching, automated learning, and computer- assisted instruction. New building spaces and building facilities that group students and provide them with alternative units of instructions in science to achieve learning objectives are now available.

The curricula and teachers are now tailored towards these developments and the school examinations are geared to testing these levels. But how can the recipients of this didactic system be lifted into the multi dimensional scientific knowledge. How would such products constitute action students in the science classroom? There are questions which science curriculum planners and educators should strive to answer.

Science education should aim at raising the students understanding above the nominal and functional literacy levels. This should empower them to lead productive lives by striving towards structural and multi dimensional science literacy. This according to Bybee (1993) has expressed the goals of science education in terms of five aims:-

i) Empirical knowledge chemical, physical, biological and technical system

ii) scientific methods of investigation
iii) personal development of the learners
iv) societal development or achieving the aspiration of the society
v) career awareness

The NSES also emphasizes teaching The NSES emphasizes teaching for meaning and understanding. McTighe, Self, and Wiggins (2004) identified five key principles necessary for teaching for meaning and understanding:

1. Understanding big ideas in context is central to the work of students.
2. Students can only find and make meaning when they are asked to inquire, think at high levels, and solve problems.
3. Students should be expected to apply knowledge and skills in meaningful tasks within authentic contexts.
4. Teachers should regularly use thought provoking, engaging, and interactive instructional strategies.
5. Students need opportunities to revise their assignments using clear examples of successful work, known criteria, and timely feedback.

All of these principles are found in the National Science Education standards and represent a shift the traditional classroom experiences. In addition to the five key principles identified for teaching for meaning and understanding, science teachers themselves identified goals that are congruent with the outcomes targeted in the standards (Pennick and Bonnstetter, 1993). The goals for students were:

1. Having a positive attitude towards science
2. Using knowledge learned to identify and solve problems
3. Developing creativity
4. Communicating science effectively
5. Feeling that the acquired knowledge is useful and applicable
6. Taking actions based on evidences and knowledge
7. Knowing how to learn science

A focus on teaching for meaning and understanding, and achieving these seven goals requires changes in teacher practices. The focus on this paper was to investigate what impact even the slightest changes in teacher practices, the curriculum and the view and nature of science education might have on the students' actions. If teacher move away from the more traditional approaches outline by Brooks and Brooks (1999), and forward more constructivist teaching based on curriculum innovations practices, which facilities teaching for meaning and understanding, will the goals science teachers have for students emerge?

2. The Science Curriculum

Firstly, the curriculum for science education in schools is usually presented in the form of core curriculum for different subject areas such as health science, basic science, agricultural science, mathematics for the primary school, chemistry, biology, physics, agricultural science, mathematics in the senior secondary schools and single or double honours in physics, chemistry, biology, etc in tertiary institutions. The problem now is, how can the educational experiences derived from these core curricula be synthesized into a 'compendium of choices' that can lift the recipient into the structural or multi dimensional scientific knowledge

Secondly, the curriculum outlines (syllabi) are presented with limited relevancy to science education Holbrooke and Raunikmae (1997) suggest that relevant science education is that which relates to issues or concerns within the society. Relevancy here relates to the students in general and the society and not science per se. For example, curriculum outline for an important concept- WATER (from SSS chemistry syllabus)

3. Topic: - Water and Solution

a) Composition of water
b) Water as solvent
c) Hardness of water and methods of removing it
d) Solutions and solubility
e) Treatment of water for town supplies

4. The Science Teacher

Considering the impact of the level of constructivist teaching had on student actions emerging in science classrooms. An example of a teacher using *fundamental approach* and his students

Topic: - Water for our use at homes and everywhere

a) Various sources of water we drink at home. How safe are the sources
b) Possible dangers and contaminants of the water from the sources. Methods of making the water /resources safer and cleaner
c) Salt and mineral in our water. What are the effects and methods for the removal
d) Electricity and water. Any relationship? What happens if current is passed through acid water?

Experimentation

e) Water, salts and other substances. Can all substances dissolve in water?
f) Village and town water supplies. What are the differences between them?
g) Bringing clean water to the villages. How can we bring clean water (tap water) supply to homes in the villages?

While the contents of the above approaches are similar to that of scientific approach, the two differs. The constructivist/ scientific approach create rooms for context teaching as well and it enhances a wide range of skill through involving students in a variety of multi dimensional activities

The teaching is tilted towards content rather than context teaching. Context teaching approach is a method in which topics are treated out of the confines of the classroom to a real life situation. For instance, when a teacher taught the students that 'pure water' refers to the absence of every other substance. When the students were taken to a town water supply purification plant, the public relation officer told them that certain substances were added to the water in order to make it pure. This created confusion among the students, as they could not understand how one could make water pure by adding other substances.

Pure water as taught by the teacher in a content, theoretical concept. Water is said to be pure when it complies with a list of specific requirements regarding taste, smell, colour, sterility and composition. Researchers have shown that context teaching is more effective than content in the development of constructivist/learning. The more the content is real and related to the learner and society the more the motivation enhances achievement and understanding.

The teacher factor has been identified as critical for the successful implementation of science education. According to (Okebukola, 1997), this factor is obviously major in explaining the deficiencies in the delivery of good quality science education generally. The problem is the teacher who does not understand or who has no interest in the nature of science itself. Many teachers behave and think scientifically base on their training but the lack an understanding of the basic nature and aims of Science. Secondly, according to (Okebukola 1997) is the problem of "teach as you were taught". And with this didactic "copy and teach" and "chalk and talk" teaching methods and unfavourable teaching environment, the science taught in the conventional classroom is a mere "web of thought too weak to furniture support but complicated enough to cause confusion". This can hardly lift the student action in the science classroom.

Unfortunately, the teacher background which is fundamentally based on core subject compartmentalization, the teacher hardly possesses competency in skills for a variety of classroom teaching. The teacher changes needed are as follows:-

a) The fundamental knowledge that the teacher must possess in order to be effective and efficient in teaching science education.
b) The appropriate changes in the actual teaching environment that can facilitate necessary learning.

Science teachers should acquire:-

a) The fundamental subject knowledge in several subject areas such as chemistry, biology, physics, technology, mathematics etc. This will enable the teacher to be effective and efficient in teaching the interconnectedness of science, technology and society (STS)

b) The teacher knowledge which refers to expertise in the complex pedagogic content Knowledge and skills needed to transform subject matter into a form of which the students can learn. The realization of such teachers would require teacher training institutions to re-design their curriculum so that 60% would be spent on subject matter knowledge and 40% on pedagogy. In addition, the state and federal governments should establish science teachers' resources centre. The centres would serve as retraining ground grounds for serving teachers in scientific and technological principle and methodologies through short-term-in-services courses, seminars and workshops. These can help upgrade teachers' subject knowledge, as well as teacher knowledge, disposition and reflection for effective teaching of science education.

5. The Challenges

The concern of science education should be to rekindle the imaginative constructs of the learner so as to empower the students to attain scientific knowledge. Teachers should adopt scientific approach in their teaching rather than the fundamental approach.

An example of scientific/ constructivist approach in teaching a topic:-

Topic: - Water for our use at home

Teacher: Ngwoma is a village where people have been fetching their domestic water from the Onumurukwa river from time immemorial

Teacher: asks students, where do you fetch your water in your village?

What are the possible dangers of fetching and drinking water from the various sources?

Suggest methods of making water from the rivers pure.

What are the differences between the water the people of Ngwoma drink from that of Owerri town.

Is there anything that can be done to make villagers drink clean water just

like the people in Owerri town?

Teacher elicits answers from students and direct discussions on each question.

The students are assigned in groups to visit the source of water in their localities and write down suggestions on how to improve their drinking water. Students are then taken to Owerri urban water supply. Group of students are required to write a report on the visit and how clean water can be made available to homes in the villages.

What is water made of anyway? Investigation. Group of students are set up to find out the composition of water using acid water. (What is and why acid water?), appropriate electrolytic cells and gas identification techniques.

Teacher: let us dissolve some salt in water and observe/measure their solubility.

Students carry out the exercise.

The teacher supervises. Calculations on solubility are carried out by the teacher /students.

Such a teaching approach is learner and society centred. For an instruction to be effective and motivational, the students must see what is being taught as having real value for him as an individual and as a member of a community.

The teaching of science should be as much as possible a stimulation of the scientific process itself. The concepts of the disciplines should be studied vigorously in relation to their knowledge base. Thus, science would be learned as inquiry. Further, the information thus learned would be retained because it is embedded in a meaningful frame (Joyce and Showers, 2002).

The science processes that occurred in the scientific approach in the classroom include:-

1) observations
2) offering approaches to problems
3) listing resources

Students initiated actions observed in scientific approach group should be frequent and harmonious with qualities of a scientifically and technologically literate person who offers explanations of natural phenomenon…..(NSTA,1990). An example of students sharing explanations occurred when these students in one class found a picture of what is been taught. The students should be comfortable articulating their ideas and negotiating with others in the classroom. The students taught with the fundamental approach may be dependent upon the teacher. They might be found more often sharing their ideas with the teacher instead of other students. Teacher confirmation occurred frequently in these classrooms.

Dewey (1963) addressed the need for increased attention to the quality of students' experiences. 'An experience may be such as to engender callousness'. It may produce lack of sensitivity and of responsiveness. Though collaboration was occurring while students were doing the experiment, the level of cognitive engagement was not as rich as those envisioned in the NSES (National Research Council, 1996). The content standards for scientific inquiry for secondary school students are:-

- Identify questions that can be answered through scientific investigations
- Design and conduct scientific investigations
- Use appropriate tools and techniques together, analyze and interpret data
- Develop descriptions, explanations, predications, and models using evidence
- Think critically and logically to make the relationship between evidence and explanations (NRC,1996)

Based on the two approaches outlined in the teaching and of the topic; water. The differences in levels of constructivist teaching practices between the two groups is likely to result in students in the scientific approach exhibiting more outlines suggested in Pennick and Bonnstetter, (1993) goals for students in science. The students in the first group taught with the fundamental approach can be compared to the traditional classrooms described by Brooks and Brooks (1996). Students in the constructivist/ scientific approach teaching group should be more often found:

1) Using knowledge learned to identify and solve problems

2) Developing creativity

3) Communicating science effectively

4) Given opportunities to recognize the applicability of acquired knowledge

5) Taking actions based on evidences and knowledge

To varying extents, the five key principles of teaching for meaning and understanding. identified by McTighe, Self, and Wiggins (2004) seemed to guide the rationale behind the teaching practices facilitating instruction in both groups.

Examples of principles that seemed to emerge were:

1) Understanding big ideas in context is central to the work of students.

2) Students can only find and make meaning when they are asked to inquire, think at high levels, and solve problems.

3) Students should be expected to apply knowledge and skills in meaningful tasks within authentic contexts.

6. Conclusion

This paper identifies the differences that can and do occur as a result of teacher practices used to facilitate science instruction. The paper not only suggests the importance of focusing on the students actions exhibited in the classroom, but also emphasizes the differences in teaching practices that lead to meaningful results. Considering students action in the classrooms as predictors of the scientific literacy allows educators to identify what is important in science education and strive to move closer the call for reform put in the National Science Education Standards.

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