REFORMS AND INNOVATION IN SCIENCE EDUCATION: THE WAY FORWARD

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Abstract
Science has been defined from many perspectives which include: an ordered and inquiry-based body of knowledge- in the form of concepts, laws and theories. Modern experimental science dates back to the 16th century, but did not find its way into School curricular immediately. Several conferences were held in 1960, 1961 and 1962 with a view to introducing an organized science education curriculum into African educational system. The formation of Science Teachers Association of Nigeria (STAN). Science Association of Nigeria (SAN) and Mathematical Association of Nigeria (MAN) were also among the initiatives and reforms in Science Education. Science Education has not fared well despite all these efforts, in Nigeria all these years, because of the economic precession which began in the 1980s, ill-equipped laboratories and brain drain among others.
In view of these unimpressive development reforms and innovation become necessary as a way of repositioning Science Education

Introduction
Science derived from the Latin word Scientia which means knowledge. Science stems from the urges and needs of the people. These needs and urges must be satisfied, hence they usually drive curious minds to seek rational answers to myriads of questions that are often raised in an attempt to understand the why and how of things. There is no universal definition of science. The definition of science varies from one scientist or scientific community to the other. However, there are some basic definitions of the subject on which we can anchor our points in this presentation. Some scientists see sciences as the what, how and why of things and happening in the environment some others define it in terms of its products and processes. Yoloye (1998), sees science as a study of nature and natural phenomena in order to discover their principles and laws. Defined
in terms of its products, science is an ordered body of knowledge in form of concepts, laws theories and generalizations. Hence, the products of science are its concepts, principles and theories.

**History of Science**

Although, modern experimental science emerged in the 16th century, the teaching of science was slow in finding its way into the formal curricula of formal educational institutions. According to Lauwerys (1957), science was given its head in industry, but had been frustrated and hamstrung in education. Science finally found its way into formal school curricula in the late 19th century in the United States of America, USA and continued in the early 20th Century in England and Wales. In other words, science go into formal school curricula centuries after its emergence (Yoloye, 1998).

In Nigeria, like many African countries, up till the early 1960’s science was given relatively little attention. In the primary schools, what many people described as Science were:

i) Nature study

ii) Hygiene

iii) Rural science

The objectives of teaching these science were simple, namely, developments of clean and healthy habits, a knowledge of nature; plants and animals and of principles and techniques of farming.

In secondary schools, Physics, Chemistry and Biology were tonight as regular school subjects. However, equipment for teaching them was inadequate and only a few secondary schools taught them. The attainment of independence in 1960 brought a new impetus. A number of international conferences in the early sixties drew the attention of developing countries especially in Africa, to the need for science and technology. Three of the most significant were the Rehovoth (Israel), 1960, the Addis Ababa conference of 1961 and the Tamanarive conference of 1962.

1. **The Rehovoth (Israel), 1960 Conference on Science in the Development of New States.**

   Two of the recommendations of the conference read as follows:

   a) The governments of developing States should regard the furtherance of science and technology as objectives of their national politics and make appropriate provisions for funds and opportunities to achieve them.

   b) Until such time as their own scientific manpower is adequate, new and developing States would be free to seek help of scientific advisers and experts from friendly countries and international agencies to help develop a scientific practice and tradition (Gruber, 1961).


   Among other important pronouncements, the conference recommended that **African**
educational authorities should revise reform the content of education in the area of the curriculum of books and methods, so as to take account of the African environment, child development, cultural heritage, demands of technological progress and economic development, especially industrialization (UNESCO, 1961).


Among other things, the conference declared that the ratio of students in scientific and technological disciplines and the humanities in higher education should be 60:40.

African countries took the issues of science and technology seriously in their drive for modernization and active steps were taken to further their development through education.

There were local initiatives such as the Northern Nigeria Region Primary Science Programme (a component of Primary Education Improvement PHP), based in Ahmadu Bello University, Zaria. The Midwest Primary Science Programme for Nigerian Primary Science Project based in the University of Ife and various efforts by the Nigerian Educational Research Council, CESAC AND THE Science Teachers Association of Nigeria (STAN).

The State of Science, Technology and Mathematics (STM) Education in Nigeria Today

In an attempt to provide an all-round technical education, the government decided to group Science, Technology and Mathematics (STM) together to form a programme. To this end,

1. The Federal Government has put in place several structures and infrastructures which have great potential for furthering STM education as recorded in Maduemezia, Okonkwo and Okon, (1995). These include:
   i) A virile Federal Ministry of Science Technology.
   ii) 18 Scientific and Technological Research Institutes
   iii) (a) The Energy Commission of Nigeria-Lagos
   (b) The Sheda Science Technology Complex (SHESTCO) - Abuja.
   (c) The National Mathematical Centre, (NMC) - Abuja
   iv) The Nigerian Educational Research and development Council (NERDC).
   v) Thirty six Universities and Polytechnics and sixty one Colleges of Education provide STM education at the tertiary level.

2. Four very virile professional association exist what actively promote STM education in the country. These are:
   i) The Nigerian Academy of Science (NAS), the apex. Scientific Organisation.
   ii) The Science Teachers Association of Nigeria (STAN)
Factors Working Against STM Education in Nigeria

1. The economic recession which has been on for over two decades has taken tremendous toll on education in general and SM education in particular. Many instructional laboratories (secondary and tertiary) are in terrible conditions.

2. Many books in use are out-of-date and there is a dearth of up-to-date journals in most tertiary institutions.

3. Scholars, especially at the tertiary level suffer a curious isolation from their counterparts in more developed countries because of lack of funds to attend scientific conferences.

4. There is massive brain drain of some of the most capable teachers in STM especially at the tertiary level.

5. As a result of these factors, the quality of instruction in science in particular has declined sharply. Much of Nigeria’s development in the direction of modernization has been haphazard leading to acquisition of obsolete technology. Amenities fail to function—electricity, water, telephone. There is marked decline in productivity at all levels. Much of our daily lives are marked by a peculiar lack of order. Some people thrive in this because it provides fertile ground for graft and corruption (Yoloye, 1982).

Reforms and Innovation in Science Education—the Way Forward

Yoloye (1998), has put forward a 4-point proposal to this effect:

1. The early part of the 21st Century should be a period of consolidation rather than expansion in terms of STM education.

2. There should be marked improvement in STM teaching.

3. Science, Technology and Society as an innovative curriculum should be introduced into STM education.

4. Science for all as a curriculum content should be introduced into STM education.

Consolidation

We can act in line with vision 2000 by setting aside some years to consolidate what we have on ground, while we plan to move forward. With the appropriate political will, we can make what we have on the ground function as required, while we halt further expansion until consolidation is complete.

Ajayi (1994), suggested three key points in the consolidation process, namely:

(i) Funding

(ii) Putting in place mechanisms for re-establishing standards and quality control

(iii) Reviewing policies which encourage undue political interference with our educational institutions.

Improving the Quality of STM Teaching

The 1960 drive for inquiry-based learning is still very valid till today though
a variant, Constructivism has also come on the scene. Yoloye (1989), proposed a four-fold set of education objectives based on Bloom’s Taxonomy:

(i) Remembering
(ii) Understanding
(iii) Thinking
(iv) Producing

In terms of learning procedure, he also proposed the following four derived from the inquiry approach:

i) Learning from discovery
ii) Learning by discovery
iii) Learning to discover
iv) Learning to produce

The essence of the last (fourth) element is to combat one of the maladies in our society – declining productivity.

The values of integrity, industry and honesty are values on which science thrives. That is why expert procedures can be replicated from one country to the other. Again, these values should be the overt objectives of STM education.

**Developing Student Abilities and Understanding in Science Education**

With an appropriate curriculum and adequate instruction, students can develop the skills of investigation understanding that scientific inquiry is guided by knowledge, observations, ideas and questions.

Teachers of science students should note that students tend to center on evidence that confirms their current beliefs and concepts (i.e. personal explanations), and ignore or fail to perceive evidence that does not agree with their current concepts. It is important for teachers of science to challenge current beliefs and concepts and provide scientific explanations as alternatives.

The instructional activities of a scientific inquiry should engage students in identifying and shaping an understanding of the question under inquiry. Students should know what the question is asking, what background knowledge is being used to frame the question and what they would have to do to answer the question. To help focus investigations, students should help frame questions such as *What do we want to find out about ..? How can we make the most accurate observations? Is this the best way to answer our questions? And if do this, then what do we expect will happen?*

The instructional activities of a scientific inquiry should involve students in establishing and refining the methods, materials and data they will collect. As students conduct investigations and make observations, they should consider questions such as *What data will answer the question? And what are the best observations or measurement to make?* Students should be encouraged to repeat data collection procedures and to share data among themselves.

**Abilities Necessary to do Scientific Inquiry**

These include the fifteen skills of Science proposed by the American Association for the Advancement of Science (AAAS). These are broadly described as follows:
Identify Questions that can be Answered Through Scientific Investigations:

Students should develop the ability to refine and refocus broad and ill defined questions. An important aspect of this consists of the students’ ability to clarify questions and inquiries and direct them towards objects and phenomenon that can be described, explained, or predicted by scientific investigations. Students should develop the ability to identify their questions with specific ideas, concepts, and quantitative relationships that guide investigations.

Design and Conduct a Scientific Investigation:

Students should develop general abilities, such as systematic observation, making accurate measurements and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry and to understand how these ideas compare with current scientific knowledge. Students should learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations and criticize explanation and procedures.

Use Appropriate Tools and techniques to Gather, Analyze and Interpret Data:

The use of techniques including mathematics will be guided by the questions asked and the investigation students design. The use of computers for the collection, summary and display of evidence is part of the standard being advocated. Students should be able to access, gather, store, retrieve and organize data, using hardware and software designed for these purposes.

Develop Description, Explanations, Predictions and Models Using Evidence:

Students should base their explanations on what they observed and on what they observed and as they develop cognitive skills, they should be able to differentiate explanation from description-providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the science and the contexts within which students develop new knowledge.

Think Critically and Logically to Make the Relationships Between Evidence and Explanation:

Thinking critically about evidence includes deciding what evidence should be and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data and form a logical argument about the cause-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables.
Recognize and Analyze Alternative Explanations and Predictions:
Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations.

Communicate Scientific Procedures and Explanations:
With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups and telling other students about investigations and explanations.

Use Mathematics in All Aspects of Scientific Inquiry:
Mathematics is essential to asking and answering questions about the natural world. Mathematics can be used to ask questions; to gather, organize and present data; and to structure convincing explanations.

Conclusion
The exposure of our school systems to these reforms is enormous, so also are the policy formulators. A good number of scientists who are products of these reforms have also been turned out over these years. The utilization or maximization of their intellectual resources has been the problem.
The policies are good, but implementation is a problem. Government development priorities have repeatedly failed to put science education at the front burner. This is more disheartening in the tertiary institutions and research centers.

We are far from being qualified as an industrializing nation. Countries which hitherto were at the same level with us some 30 years ago have moved into the committee of industrializing world. Whether we like it or not, science rules the world. We should work desperately hard to shed the ugly coat of a consumer nation. The panacea is the full implementation of the reforms and innovations that have been extensively dealt with in this paper. The task is not only for government, but all of us.

References

