STAN MEMORIAL LECTURE 2011

PRACTICAL WORK IN SCHOOL SCIENCE: ARE THE AIMS AND OBJECTIVES BEING ACHIEVED?

PRESENTED AT

THE 52ND ANNUAL CONFERENCE OF THE SCIENCE TEACHERS ASSOCIATION OF NIGERIA, AKURE

BY

PROFESSOR DURO AJEYALEMI

Visiting Professor, NUC/Technical Adviser,

Permanent Secretary' Office,

Federal Ministry of Education, Abuja

Introduction

- The three major dimensions to science are its content (scientific knowledge), its method (scientific processes) and its applications (which may result in tangible products).

- Scientists apply the scientific method to conduct inquiry into nature in order to obtain scientific knowledge.

- This they do, by using processes such as observing, classifying, hypothesizing designing experiments, measuring, communicating, interpreting data, etc.

According to Millar (2004), the aims of any science education can be summarized as

- "to help students to gain an understanding of as much of the established body of scientific knowledge as is appropriate to their needs, interests and capacities
- to develop students' understanding of the methods by which this knowledge has been gained and our grounds for confidence in it (knowledge *about* science)".

- The second aim is on '**understanding the nature of science'** and it includes "*an understanding of how scientific inquiry is conducted, of the different kinds of knowledge claims that scientists make, of the forms of reasoning scientists use to link data and explanation, and of the role of the scientific community in checking and scrutinizing claims*"(Millar, 2004)

Practical work

- **Practical work is defined as "*any teaching and learning activity which involves at some point, the students manipulating real objects and materials*" (Millar, 2004)**

Purpose of Memorial Lecture

- to review the aims and objectives of practical work in science teaching, the designs of practical work for these objectives and the levels of their achievement, particularly in the Nigerian context

Aims and Objectives of Practical Work in School Science

- **According to the old Confucius saying, "*I hear and I forget; I see and I remember; I do and I understand*". That is, learning is likely to be enhanced if we do things ourselves than if we are shown or told. This has been one of the rationales for making science students do practical work. Thus, engagement of science students in practical activities is recommended in science curricula world-wide. It should enable…**

- ***"students to use information, to develop a general concept, to determine a new problem, to explain an observation or nonconformity in nature, or to make a decision. Laboratories are active places where the unknown is confronted"*** (Yager, 1990).

Kerr (1963) listed the following aims:

- encourage accurate observation and careful recording.
- promote simple common sense scientific methods of thought.
- develop manipulative skills.
- give training in problem solving.
- fit the requirements of practical examination regulations.
- elucidate the theoretical work so as to aid comprehension.

- verify facts and principles already taught.
- be an integral part of the process of finding facts by investigation and arriving at principles.
- arouse and maintain interest in the subject.
- make biological, chemical and physical phenomenon more real through actual experience.

Trowbridge & Bybee (1990) also suggested a list of eight goals for practical work:

- To develop skills in problem-solving through identification of problems, collection and interpretation of data, and drawing conclusions.
- To develop skills in manipulating laboratory apparatus
- To establish systematic habits of record keeping
- To develop scientific attitudes
- To learn scientific methods of solving problems
- To develop self-reliance and dependability
- To discover unexplored avenues of interest and investigation
- To promote enthusiasm for the subject of science.

Organization of Practical Work

- Two major types of science practical work have been adopted by teachers to make students achieve one, some or all the objectives of practical work. These are: the ***verification*** and the ***problem-solving*** types.

Verification

- **In the verification type, students are put in the position of past scientists but, they are merely trying to repeat and confirm experiments that were done in the past and which are now incorporated in textbooks or workbooks. The laboratory is then a place for checking out what the teacher or textbook says.**
- **For example, students may be asked to carry out activities to confirm Boyle's or Charles's Laws, or they may be trying to show that air is present around us. Students are given all the instructions and provided with all the required apparatus and materials; they are simply to comply in the typical *cook-book* fashion. This has been the predominant type in Nigerian schools where practical work had been held at all.**

Problem-solving

- In the problem-solving type of practical work, the student is encouraged to solve a problem identified either from the textbook or from everyday experiences of the teacher, students and/or community. Whatever the source of the problem, the solution process will require the use of the scientific method. For example, the newspapers might have reported that government is distributing some fertilizers to farmers in order to improve agricultural yield in that community and this may become the issue for the science class to deliberate upon.

- In a brainstorming session in class, for instance, the students and teacher may have arrived at an hypothesis that the use of some nitrate fertilizers could lead to the pollution of the local environment.

- The problem for students may then be to determine whether the fertilizers distributed contained nitrates and if the concentration of trioxonitrates (V) in the ground water supply is enough to cause pollution of the community's water supply.

- The result of the investigation would now enable the students to convince the Water Board and agricultural authorities to take urgent action.

- The problem-solving type of practical work may be accomplished by ***free inquiry (discovery)*** or it may be ***guided*** by the teacher. The free inquiry type **involves students, on their own, defining the problem of study and finding solutions to the problem un-aided**; there are no fixed solutions and students may come up with several different methods of solving the same problem.

- The free inquiry type is not commonly employed in school science because it is time consuming and costly. Also for many science educators, it is unlikely for students to be able to 'discover', in about 90-120 minutes, what took renowned scientists many years to find. The free inquiry type appears more appropriate for final year university research projects.

- **Practical work in the guided-inquiry mode can be designed in several ways; each form of organization describing a different level of guidance involved, e.g.,**

- *Lecture-Demonstration*
- *Class-assisted Demonstration*
- *Detailed Worksheet*
- *Loosely-structured problem-solving*
- *Projects*
- *Field Trips*

Loosely Structured Design

- **perhaps, the most acceptable for achieving most of the objectives of practical work. It:**
  - **is more student-centred**
  - **allows students to engage in authentic investigative and higher-order thinking processes**
  - **provides opportunities for many of the aims of practical work to be fostered.**
- **however it is time-consuming, may be costly and very demanding on teachers and students**

Project Work

- Best method for teacher to provide opportunities for students to "act like expert scientists conducting research"
- wonderful way for students to get a real sense of science;
- students get opportunities to, among others:
  - work independently
  - delve as deeply as time permits into problems of special interest to them
  - learn cooperatively
  - create, build and construct ideas/things.

Field Trips

Some Guidelines for Planning a Visit

- **Ensure that the trip will contribute to the current objectives of the class.**
- **Make and confirm preliminary arrangements with appropriate personnel in the company; if possible, the teacher should visit the site him/herself before taking students.**
- **Prepare students for the trip by involving them in planning the objectives, the activities, and required behaviours**.

- **Identify and plan possible outcomes of the trip in relation to future class work, e.g., students' projects, class discussion or laboratory work related to content already or not yet covered.**
- **Ensure an adequate transportation arrangement.**
- **Obtain written permission from the school administration, and the parents of students.**
- **Notify other teachers whose lessons the students might miss, and arrange for how to cover the lessons.**
- **Provide time for evaluating the effectiveness of the trip, e.g., through class discussion after the trip.**

- *------ the laboratory (i.e., practical activities) must precede the introduction of an abstract generalization. The more traditional method of conducting laboratory activities is to introduce the concept (abstract generalization) in a lecture prior to the laboratory experience…..*

(Lawson and Renner, 1975)

Post-Practical Activities

- Data from any type of practical activities need to be analyzed and interpreted for them to be meaningful and contribute to mental growth. It is from such analyses and interpretation that the relevant concepts and principles will be learnt. So Lawson and Renner (1975) continue:

- *Data from an experiment must be shared, discussed, retaken, and re-discussed. Students should converse, share experiences and argue. ------The fact of the matter is, all of the concrete experiences in the world will not facilitate the acquisition of abstractions unless it is accompanied by social interaction via the use of language. The factor of social interaction is invaluable; however, like concrete experiences, it alone is insufficient because the learner can receive valuable information via education only if he is in a state in which he can understand this information. That is, to receive this information, he must first have a set of concrete experiences that provide him with a variety of sensory images to serve as reference points which ground the verbal elements….*

- **Thus, with such discussions, both the data collection phase and the data interpretation phase constitute the *practical work task*. The aim is to "draw students' attention to a phenomenon, to isolate parts of it for particular scrutiny, and to talk towards a way of thinking about it" (Millar, 2004).**

Outcome of Practical Work

- **Students often do not learn from practical activity what is intended by the teacher. Thus, the contributions of practical work to learning have been queried:**
  - **as practiced in many countries, it is ill-conceived, confused and unproductive (Hodson,1991). Also,**
  - **practical work only has a strictly limited role to play in learning science and that much of it is of little educational value (Osborne, 1998) .**

Science Practical Work in Nigerian Schools

Objectives of the science curriculum at the Basic level, are to enable the learners to:

- **develop interest in science and technology**
- **acquire basic knowledge and skills in science and technology**
- **apply their science and technology knowledge and skills to meet societal needs**

- **take advantage of the numerous career opportunities offered by science and technology**
- **become prepared for further studies in science and technology (NERDC, 2007).**

At SS level, students to be provided:

- *continuous experiences in defining problems, recognizing assumptions, critical thinking, hypothesizing, observing, collection and recording of data, testing and evaluating evidence, manipulating variables, generalizing and applying generalizations.*

Achievement of the Aims in Nigeria

- **At the primary level, there is little or no science taught, and so little opportunity for pupils to practise "what scientists do".**
- **At the JS, the teacher engages more in information giving and/or the lecture-demonstration type of practical activities, which is highly teacher-centred.**
- **At the SS, students are not normally exposed to laboratory activities, until, may be, a few months before the SSCE in most schools (Aramide, 1985, Abimbola, 1994)**

- **Teachers often rush to complete teaching the "overloaded" syllabuses (Adesoji and Arowosegbe (2004)**
- **The main aim of practical work at the SS level in Nigeria may then be to meet the requirements of the SSCE Practical Examinations.**

- **Thus, students have very little opportunities** *in defining problems, recognizing assumptions, critical thinking, hypothesizing, observing, collection and recording of data, testing and evaluating evidence, manipulating variables, generalizing and applying generalizations* ***as envisaged by the science curricula.***

Conclusion

- **If practical work has not been achieving many of the aims, even in educationally advanced countries where the needed human and material resources have been provided in abundance (Hodson, 1991; Osborne, 1998; Maskill, 2000), how much more would it be a problem in our under-served learning environment? We can safely conclude that the salient aims and objectives of practical work are not being achieved in the Nigerian school system.**

- **This may be attributed to**
  - **the poor learning environment and**
  - **the fact that notwithstanding what the curriculum recommends we, teachers, have remained inflexible in our methods of teaching.**
  - **Teachers adhere mainly to the lecture-recitation pattern of instruction in spite of what our methodology courses teach us.**
- **Granted there is a shortage of needed resources, experience still shows that even in well equipped schools, many teachers do not use the facilities as required.**

- **The importance of practical work in science and in science teaching is un-debatable, therefore, every effort must be made to implement the various curricula as intended. A concrete presentation of the abstract science content is needed for our students to meaningfully learn; they should be taught the related concepts before carrying out practical activities or both theory and practice should be integrated to elucidate the theories and principles**

- **That is, for a meaningful science education and for science to serve the needs of development in Nigeria, the implementation of practical work in our school science is a *sine qua non.***

- **All the stakeholders, especially government, must play their roles in this. The STAN needs to be more vehement in its demand for minimum provisions for the teaching of science as science.**

- **Governments must provide the necessary human and material resources.**
- **Teachers must be alive to their responsibilities and be committed to change.**
- **Science teacher educators must review their teacher preparation curriculum programmes to ensure that science teacher-trainees are themselves exposed to all the practical activities in the different curricula during training.**

- **Teachers, particularly at the primary level must be updated in content knowledge and pedagogy.**

- **It may then be necessary to mount intensive continuous education programmes to re-orient science teachers on the proper implementation of the curricula.**

- **The suggestion in literature for 'alternatives to laboratory work', including exposing students to video-taped recordings of well-planned demonstrations and computer simulations of experiments, can only support but cannot replace actual practical activities.**

- **Whatever the argument for or against the impact of practical work on students' learning outcomes in science, it is incontrovertible that engagement of students in practical activities, would make their learning more concrete and aid the acquisition and development of many life-coping skills.**
- **As concluded by Millar (2004) "Practical work is an essential component of science teaching and learning, both for the aim of developing students' scientific knowledge and that of developing students' knowledge *about* science". I cannot agree more!**

- Thank you for listening