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HOW TO USE THE LABORATORY AND CONDUCT PRACTICAL FOR SKILLS AQUISITION FOR SECONDARY SCHOOL STUDENTS

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A well designed Laboratory creates opportunity for students to learn science concepts meaningfully, acquire scientific skills and scientific attitudes. Thus it is imperative that teachers acquire skills in designing laboratory activities to provide students deep understanding of science concepts for them to apply these concepts in solving practical problems. This paper provides an outline of major functions of the laboratory, skills in organizing laboratory activities, and how science practical work can be effectively assessed to encourage students' use of science skills in solving problems. Teachers often use the product-based assessment in which marks or grades are awarded on how close a student's results are to the target value. Researchers have shown that the process-based assessment in which grades are given based on whether students perform some operations correctly or not is more effective as it ensures close supervision of students by the teacher which motivates students to be more attentive and thorough in carrying out practical activities in the laboratory. A process-based criteria for assessment of practical skills was provided as a model for teachers who intend to use them or construct other process-related assessment criteria for assessment of other skills.

Keywords: Laboratory, Skills, Secondary, Schools, Nigeria

INTRODUCTION

Science education is based on empirical data which are acquired through practical pursuits and activities. These activities are usually laboratory-based and involve a well planned design to provide the investigator ample opportunity to make observations, formulate hypotheses, collect data and interpret them to provide some logical explanation to observed phenomenon. The ability to design fruitful experiments, collect and accurately interpret data can only be perfected through constant practice in the laboratory. The major significance of teaching science is therefore aimed at helping students to acquire dexterity in the use of these skills through involvement in well designed laboratory activities. No matter how equipped a laboratory, the role of a teacher that lacks ability to design and direct laboratory activities may be limited to that of a store keeper.

A well designed laboratory creates opportunity for students to learn science concepts meaningfully, acquire scientific skills and scientific attitudes. For students to have deeper understanding of the key concepts and fundamental principle of science, the process involved in generating these concepts and principles must be learnt (Mari, 2001). It has been pointed out in Wins cousin Bulleting No. 161, that 'because man both designs the observation system, selects and groups pertinent observation from the system, one must understand the processes employed in generating observations and concepts if one is to understand and use concepts'. It is expected that skills learned and developed through practical work in science can be transferred to context in other areas of the curriculum and indeed into the everyday life of the pupils (Lock and Foster, 1987). Researchers show that our classes are devoid of facilities and activities that provide secondary school students deep understanding of science concepts, so as to effectively apply them to solve problems (Arokoyu and Ugonwa, 2012; Aderanti, 2013)

As patriotic teachers, we are at a cross-road. We are faced with no or empty laboratories, large class size, and meager salary at our disposal. In the midst of all these problems, we must note that the future survival of our nation depends on us. As true patriots and "unfortunate" people in the noblest profession in the world, we must put hands in a framework that will broaden our vision of impression to include not only substitute for apparatus but the initiation of scientific problems related to our environment as well as evolve practices which will motivate our young scientists to continue to engage in scientific enquiry. The meager resources and facilities at our disposal should not deter us from putting in our best towards improving activities and environment that will allow students generate science problems as well as design experimental procedures that will provide solution to the problems through use of appropriate scientific practices. According to Shuaibu and Otuka (1989), students will eventually become self-propelling in their pursuit of science after enjoying these activities a few times and need no extra coaching at the approach of examination or fraudulent practices to pass examinations.

The Laboratory and Its Function

Laboratory could be defined as an instructional facility for acquisition of scientific skills, attitudes and organized knowledge about the universe. A laboratory therefore provides an avenue for students to learn what science is and how scientists work (Mani, 1985). The following cognitive, affective and science skills are acquired from the laboratory:

1. Product of science i.e. knowledge and understanding of:

a. Scientific phenomena, facts, laws, definitions, concepts, theories
b. Scientific vocabulary, terminology, conventions
c. Scientific instruments and apparatus, including techniques of operation and aspects of safety.
d. Scientific quantities and their determination
e. Scientific and technological application with their social, economic and environmental implications
f. Ability to remember, understands, apply, analyze, synthesize and evaluate information.

2. Skills and ability to:

a. Observe, measure and record accurately and systematically
b. Follow instructions accurately for the safe conduct of experiments
c. Communicate scientific observations, ideas and arguments logically, concisely and in various forms.
d. Translate information from one form to another
e. Extract from available information data relevant to a particular context
f. Use experimental data, recognize patterns in such data, form hypotheses and deduce relationships
g. Draw conclusions from, and evaluate critically experimental observations and other data
h. Recognize and explain variability and unreliability in experimental measurements.
i. Devise and carry out experimental or other tests to check the validity of data, conclusions, and generalizations.
j. Devise and carry out experiments or test for particular purposes, selecting suitable apparatus and using it effectively and safely.
k. Explain familiar facts, observations and phenomena in terms of scientific laws, theories and models.
l. Suggest scientific explanations of unfamiliar facts, observations and phenomena.
m. Apply scientific ideas and numbers to solve qualitative and quantitative problems.
n. Make decisions, based on the examination of evidence and arguments.
o. Recognize that the study and practice of science is subject to various limitations and uncertainties.
p. Explain technology of science and evaluate associated social, economic and environmental implications (Kempa, 1986:17).

3. Development of scientific and positive attitudes toward science and science based career:

a. To show favourable attitudes to science and scientists
b. To accept scientific enquiry as a way of thought
c. To develop interest in science and science based activities

d. To acquire scientific attitudes, like honesty, humility, perseverance, open mindedness and skepticism.

These goals can hardly be realized if teachers stick dogmatically to the usual verification and examination oriented activities conducted in our laboratories. As science teachers, we must creatively engage in improvising very rich varieties of activities that will ensure that future generation is not handicapped in acquisition and application of any of these skills.

Organizing the Laboratory to Maximize Its Use

The following procedures should be adopted by science teachers to ensure hitch free preparation and administration of laboratory activities:

a. Storage and easy retrieval of materials/procedures. Chemical should be stored systematically, preferably in alphabetical order. A piece of small plank could be used to divide storage shelves into partitions and the partitions labeled using letter alphabets A-Z. The first alphabet that the name of the chemical begins with corresponds with the letter used to label the partition it is stored in.

b. Smaller bottles should be kept in front of larger bottles for easy location and retrieval in time of need

c. Reagent bottles frequently used should be kept on tables, racks or open shelves fixed to the wall.

d. All containers should be stored in single rows and never banked.

e. Reagent bottles should never be completely filled. However, substances that form explosive peroxides during storage should be completely filled and as they are used up, they should be transferred to smaller containers or glass beads be added to displace the air.

f. All reagent bottles should bear the full name, concentration, date of preparation and chemical hazards should be clearly marked on all reagent bottles.

g. All chemical stocks should be examined regularly; any which show sign of deterioration should be disposed of with great care. Chemicals which have no further use or for which the use is not known should be disposed off by the recognized methods.

h. Put away any apparatus no longer required and breakable materials should not be kept with unbreakable ones.

i. There should accurate, visible and legible labels showing contents of all drawers, boxes, cupboards etc

j. Generally a good storage system should adopt the following principles:

i Accessibility- the most frequently used items like Bunsen burner, tripods, stands, basic glassware should be stored closed to working positions in the laboratory itself.

ii Indexing and retrieval- as the number and range of resources in the department increases, a carefully designed and simple indexing system becomes mandatory. Alphabetical card-index files have the advantage of flexibility and are more easily kept up to date than book files. The card-index or book files should contain storage place for each items to assist in visual checks on the availability of an item and its retrieval and return after use.

k. The use and maintenance of apparatus in school laboratory:

i care in handling

ii minimum quantity of chemicals should be used to avoid wastage

iii any breakage should be reported and apparatus should washed with scurrying powder or soap solution and dried immediately after use

iv the iron apparatus e.g. needles, scalpels, scissors, forceps etc should be washed, dried and greased after use

v cold apparatus should not be heated suddenly and the apparatus should not be cooled suddenly

vi all objective lenses and eye pieces should only be cleaned with lens tissue paper or the softest fabric

vii microscopes, micro projectors and the projectors should be used carefully, instructions for such apparatus should be read carefully before use

viii to avoid contamination of reagents, cork or stopper should not be interchanged for reagent bottles. All laboratory users must learn to hold the stopper with the left hand and the reagent bottle with the right hand to ensure they are returned immediately after use.

l. Routine examination

Once a year and preferably during holiday period there should be full scale checking of the inventory of all equipment and materials to determine consumption rates, faults etc so that new orders can be made and repairs effected once a year.

m. Repair work

i all faulty apparatus should be repaired

ii lock and hinges should be oiled

iii brass apparatus should be cleaned with brasso

iv modern apparatus should be polished

v the laboratory tables and working benches should be waxed or polished

Procedures for Organizing and Directing Laboratory Activities for Secondary School Students

The teacher decides or initiates the practical work to be introduced at any point in time. For whatever reason the choice is made, he should outline the specific objectives he hopes to achieve at the end of the activity. He must also have a fore knowledge of the procedures and equipment the students may request so that they can be assembled before the time of execution.

At the beginning of the practical, the teacher introduces the problem to the class and then allows them time to think about how they would solve the problem and to discuss among themselves the experimental plans and make choice of materials/equipment they will use. The discussion could involve the whole class or done in groups depending on the objectives and the kind of work the teacher intends to engage the students.

The teacher at this point shares ideas with the pupils in order to help them arrive at a correct experimental procedure. Students, having agreed on a procedure, collect apparatus and set up the experiment.

Students may be asked leading questions or be provided with comprehensive that will serve as procedural guide depending on the level or students experience.

The students are then allowed to make observations and record them. The teacher provides help to individuals, or the various groups to make sense of their observations.

Summaries of their findings, interpretations, predictions etc are discussed before the end of the class.

The practical should terminate 15 minutes to the end of the class to enable them wash up and clear their tables.

The Assessment of Practical Work

According to Kempa (1986:20) experimental work in science can be grouped into five broad stages as follows:

i. The perception and formulation of a problem to be solved by practical means;
ii. The designing and planning of an experimental procedure for solving the problem;
iii. The setting up of the experiment and its execution;
iv. The conduct of measurements and/or observations and their systematic recording;
v. The interpretation and evaluation of the experimental observations and data.

Of all these activities as outlined above, only steps iii and iv that involve the use of psychomotor skills in operation. For this reason, it is widely accepted that abilities can readily be measured by means of written tests and examination. Most examination boards, for example Assessment of Performance Unit (APU) incorporate into their theory examination questions designed to test student's knowledge of experimental procedure, and their ability to interpret data and information.

Two mode of assessment techniques are often employed in assessment of practical. The first is the process-related assessment, which involves assessment and direct observation of students' actions and activities. The second method involves assessment of the outcomes or results obtained from practical work. In assessing the later, marks or grades are awarded on bases of how close a student result is to the target value, while the former is assessed by awarding grades on the basis that students do or do not perform some operations. Proponents of process related mode of assessment argue that the method is diagnostic as it provides immediate feedback on students' lapses in executing experiments. It enforces close supervision of students by teachers, which may motivate students to be more attentive and thorough in carrying out experiments. Arguing in support of process-related mode, Kempa (1986) observed that practical exercises and tasks in science readily divide into a number of subtasks each of which can be subject procedural errors and inaccuracies. Errors according to him in one of the subtasks adversely affect the final outcome of the overall exercise. Similarly, errors committed in several subtasks may compensate one another, with the effect that an acceptable result is obtained without the practical performance itself having been satisfactory. For grading to be objective, process-related performance criteria are required. An example of process-related performance criteria is shown below which can be used in assessing skills acquired by secondary school students in preparing solutions.

Process-related assessment schedule check list version
Preparing 1M solution of NaOH

1. Was the weight of base correctly taken in a weighing bottle? Yes [ ] No [ ]
2. Was the base transferred into a beaker to dissolve the solid? Yes [ ] No [ ]
3. Was the weighing bottle rinsed properly and the washings added to the beaker? Yes [ ] No [ ]
4. Was the base solution in the beaker transferred into the volumetric flask using a funnel? Yes [ ] No [ ]
5. Was the beaker rinsed properly using distilled water into the volumetric flask? Yes [ ] No [ ]
6. Was the funnel rinsed thoroughly into the volumetric flask? Yes [ ] No [ ]
7. Was the flask correctly filled to the mark before the solution was thoroughly mixed? Yes [ ] No [ ]
8. Was the flask stopper fixed and turned upside down to mix thoroughly? Yes [ ] No [ ]

CONCLUSION

In this paper, it was emphasized that involvement in practical work enhances the level to which skills are developed by secondary school students irrespective of whether they are cognitive, psychomotor or affective skills. It is expected that skills learned and developed through practical work in science can be transferred to context in other areas of the curriculum and indeed into the everyday life of the pupils. Students learn science meaningfully as they talk to others about observations and inferences they have made. They have the opportunity to put things in their own words, share the views of others, and sometimes modify their own thoughts as a consequence. This provides a sound base for understanding and applying these concepts.

Teachers, no matter the limited resources at their disposal are encouraged to improvise activities that will enable these secondary school students learn what science is and how scientists work.

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