
Teaching and Measuring Teaching Performance in Science

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Abstract

The measurement of teaching performance has been a herculean task. Many devices and processes have been used in trying to find out how effective teachers are both qualitatively and in quantity. This work is an attempt to explain and expound what teaching is, some methods of teaching in science, proffer ways out in measuring the performance of teaching in science and finally anchor on how colleagues and students measure the performance of teaching in any given setting.

Keywords: Teaching, Measuring Teaching, Performance, Science, Science Education, Schools

INTRODUCTION

Educational institutions, be they primary, secondary or tertiary are established to solve identified problems of society. For instance, primary schools are established primarily to address the problem of illiteracy, numeracy, and effective communication; the secondary schools provide vocational skills as well as preparation for tertiary education; the tertiary take care of manpower development among others. In all these, there lies a common denominator that runs through them. That denominator is "teaching".

Like the concept "education" the term "teaching" is not easy to pigeonhole into any comprehensive linguistic pattern. This is because teaching as a complex pedagogical behaviour changes with individual teachers, learners, learning activities and level of education. In spite of this predicament, many educationists have tried one definition or another or even made efforts to either describe or explain it. Among such is Dienne (1994) who says that teaching could be conceived to mean a doctrine or body of knowledge, or an occupation of those who educate, and ways of getting others to know something in the routine of the school. As a body of knowledge, he sees teaching as the accumulated pertinent knowledge, which any individual wanting to specialize in it has to imbibe. As it relates to a doctrine, he observes that certain information and ideas are held in common by all members of a given religious body. Viewed from this perspective, religious sects such as Christianity and Islam among others are held together by the specialized body of knowledge and doctrines that characterize them. Looking at teaching along this line, portrays it as a body of ideas or system of beliefs held by that group of believers as put forward by their founders. Hence, we hear the teaching of Christ or teaching of Mohammed etc.

As a vocation, he says of teaching as an occupation or profession of selected group of people who educate. From this perspective, teaching is seen as the involvement of an occupation of specialized group of people who play their specific roles and are paid by the society in which they operate. But in every day usage, teaching is conceived of as "imparting knowledge. This implies that the teacher gives the learners some of his cherished wisdom, usually made up of an abundance of facts and other supposedly true information. This definition may not be adequate for the 21st century experience, because knowledge of facts and information is but a small part of what we do in the school.

Pulias and Young (1969), describe teaching as a means of guiding learners in securing the amount and quality of experience which will promote the optimum development of their potentials as human beings. Logan and Logan (1971) look at teaching as a creative process which involves an imaginative person, who utilizes prior experiences, combines materials, methods, ideas and media in new and exciting ways which help learners integrate learning and reinforce concepts. Agina-Obu, Uriah and Oji (2011) defined teaching, as a conscious effort made by a more knowledgeable and experienced person on a learner in an activity intended to produce a change in his behaviour. This means that the intention of teaching is to produce learning.

Purpose of Teaching

As teaching proceeds, the teacher gives instructions; sometimes he indoctrinates, he trains the learner, initiates him into something new, sometimes through the process of socialization, he is involved and makes the learner participate in the process of adaptation. These educational processes of instructing, indoctrinating, training, initiating and adapting are all embedded in the teaching learning process. The learning that takes place as a result of effective or successful teaching might generally be geared towards the development in the cognitive, affective and psychomotor domains of the learner. In summary, effective or successful teaching is geared towards a well-organized and gradual development and/or modification of knowledge, attitude and skills.

METHOD OF TEACHING SCIENCE

There are different methods employed in the education of different disciplines and science is not an exception. Good science education is true to the students, true to life and true to science. The teaching of science is to inculcate into the students some scientific values and to align their psychology in line with scientific thoughts. The aim of science education presupposes a view of science, its methods, scope, and limitations. Being abreast with the nature of science will go a long way in the later discussion and better understanding of the methods of teaching science.

NATURE OF SCIENCE

The inquisitive and imaginative tendency of man about the world around has caused different ways of responses. One kind of response from earliest times has been to observe the physical and biological environment carefully, look for meaningful patterns and relations, make and use new tools to interact with nature, and build conceptual models to understand the world. This endeavour in summary is called science. Science is a progressively expanding body of knowledge covering over new domains of experience in a methodical manner. The scientific method involves several interconnected steps: - observation, looking for regularities and patterns making hypotheses, devising and deriving qualitative and quantitative mathematical

models, deducing their consequences, verification or falsification of theories through observations and controlled experiments and thus arriving at the principles, theories and laws governing the physical world.

In the steps mentioned above, there is no strict order; a theory may suggest a new experiment and at other times an experiment may suggest new theoretical models. Speculation and conjectures have a place in science but a scientific theory must be verified by relevant observations and/or experiments to be acceptable. The laws of science are not viewed as fixed essential truths, they are always regarded as provisional, subject to modification in the light of new observations, experiment and analysis; this applies even to established and universal laws of science.

The methodology of science and its demarcation from other fields continue to be a matter of philosophical debate. Its professed value neutrally and objectively has been subject to critical sociological analyses. While science is at its best is an understanding of simple linear systems of nature, its predictive or explanatory power is limited when it comes to dealing with non-linear complex system of nature (White, 2001). Despite all limitations and critical insinuations, science still remains unquestionably the most reliable and powerful knowledge system about the physical world known to man. Science is also a social endeavour since it is knowledge and knowledge is power. Science has the potential to be beneficial or harmful, emancipative or oppressive. The emancipative tendency of science can be exploited through information, transparency and tolerance for multiple viewpoints. Science tempered with wisdom is the surest and the only way to human welfare. This conviction provides the basic rationale for science education.

Good science education is regarded as one that is true to the learner, true to life, and true to science. This observation naturally leads to some basic criteria for validating a science curriculum as suggested below:

Cognitive Validity: This requires the content, process, language and pedagogical practices of the curriculum which are, within the cognitive reach of the learner.

Content Validity: This requires that the curriculum must convey significant and scientifically correct content. Simplification of content which is often necessary to adopt the curriculum to the cognitive level of the learner, must not be so trivialized as to convey something basically flawed or meaningless.

Process Validity: This requires that the curriculum engage the learner in acquiring the methods and process that lead to generation and validation of scientific knowledge and nurture the natural curiosity and creativity of the learner. Process validity is an important criterion since it helps the learner to learn science.

Historical Validity: This requires that the science curriculum be informed by a historical perspective, enabling the learner to appreciate how the concepts of science evolved with time. It also helps the learner to view science as a social enterprise and understand how social factors influence the development of science.

Environmental Validity: This requires that science be placed in the wider context of the learner's environment, local and global, enabling him/her to appreciate the issues of the interface of science, technology and society, and preparing him/her with the requisite knowledge and skill to enter the world of work.

Ethical Validity: This requires that the curriculum promote the values of honesty, objectivity, co-operation, freedom from fear and prejudice, and develop in the learner a concern for life and preservation of the environment.

AIMS OF SCIENCE EDUCATION

The general aim of science education has a direct bearing with the six contents of validity. The aims are to enable the learner:

- Know the facts and principles of science and its applications, consistent with the stage of cognitive development;
- Acquire the skills and understand the methods and processes that lead to generation and validity of scientific knowledge;
- Develop a historical and developmental perspective of science and to enable them view science as a social enterprise;
- Relate to the environment (Natural environment, artifacts and people), local as well as global, and appreciate the issues of the interface of science, technology and society;
- Acquire the requisite theoretical knowledge and practical technological skills to enter the world of work;
- Nurture the natural curiosity, aesthetic sense and creativity in science and technology;
- Imbibe the value of honesty, integrity, cooperation, concern for life and preservation of environment; and
- Cultivate 'scientific temper', objectivity, critical thinking and freedom from fear and prejudice.

SCIENTIFIC METHOD

The scientific method is an essential method in teaching of science. It involves a set of techniques to investigate a phenomenon, acquire new information, and also verify, correct, or integrate previous information based on the facts and figures or evidences available. The scientific method comprises asking and finding answers to a problem by way of logical thinking, carefully weighing all the possibilities and arriving at the best possible solution. This is made possible by making observations and conducting experiments. It can be used by the learner to understand the objects, activities and acquire the skills in decision making and problem solving. The solutions or results from this method can be applied to the living environment for the teacher to apply in solving life challenges. The teacher should:

- Arrange a necessary environment to understand the problem;
- Guide the learner to collect the data or information;
- Help in classification and arrangement of data or information in a desired order
- Formulate the hypothesis and test same;
- Help to prepare a report on tested hypothesis; and
- Give a life situation to enable the student utilize the solution to find the result.

To be able to achieve the above, a science teacher must possess the following characteristics:

- Should be open minded;
- Should have interest in seeking accurate knowledge in searching for the truth;

- Should be objective in nature i.e. analyze all happenings without any prejudice or bias;
- Should not be superstitious or rather not bound by superstition;
- Should solve the problems based upon the evidence and results of scientific methods;
- Should base his/her opinion and conclusions on adequate evidences only; and
- Should identify the measures to develop scientific attitude among the students.

ADVANTAGES OF SCIENTIFIC METHOD

- Encourages independent problem solving attitude;
- Encourages independent learning process;
- Encourages highly motivated learning by experience;
- Enhances the motivation and self-confidence in learning;
- Encourages learners to solve problems scientifically, and to arrive at new valid solutions;
- Impacts good skills and training; and
- Develops learner's skills in data collection, analysis and relevant interpretation.

DISADVANTAGES OF SCIENTIFIC METHOD

- Time consuming;
- Learners need to work hard for a longer period; and
- Needs much teacher competence as to avoid the collapse of teaching -learning process.

OBJECTIVES OF SCIENTIFIC METHOD

- To develop the scientific attitude;
- To develop the scientific temper;
- To bring to awareness, the problems associated with science;
- To make known the relationship between the nature and biotic factors;
- To encourage curiosity and creativity in science and its applications;
- To acquire the skills of:
 - Data collection;
 - Data processing;
 - Derivation of conclusion;
 - Validation of results;
 - Application of validated results.

STEPS IN SCIENTIFIC METHOD

A Scientific method has the following steps:

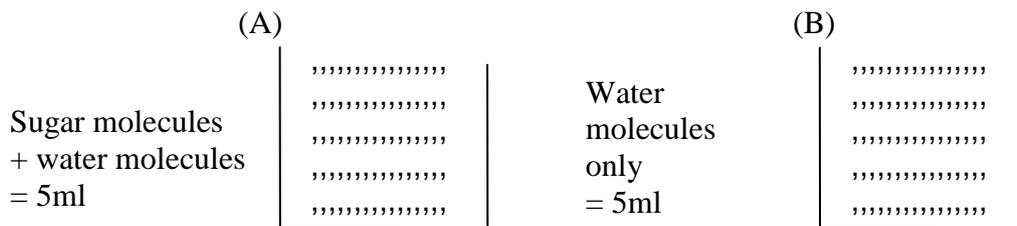
- Realizing the problem;
- Defining the problem;
- Analyzing the problem;
- Collection of Data and Relevant Information;
- Analyzing the information;

- Framing the hypothesis;
- Verifying the hypothesis;
- Draw a conclusion;
- Finding the solution; and
- Applying the solutions in life situation.

❖ **Realizing the Problem**

The initial step in scientific method of teaching and learning is the setting of the goal or realizing the problem. In this, the object of curiosity is identified. The teacher introduces the concept in the form of a problem and arouses the interest of the students to find out the solution to the same. The teacher may employ the guided discovery method of teaching here (see figure 1).

Figure 1: Example:



Observation: Water flows from (B) to (A)

Curiosity: Why does water flow from (B) to (A)

The teacher informs the students that water moves from a region of high water potential to a region of low water potential, hence, from B to A.

Teacher's Position

- Teacher introduces the concept of osmosis & water potential;
- Guides the students to discover the contents of A and B;
- Instructs the students to find out what makes B to have a higher water potential than (A).

=> **Discovery:** The students discover that:
 5mls in A = Water molecules + Sugar
 5mls in B = Water molecules alone
 B has higher water potential than A (i.e. water molecules are more in B than in A)

Conclusion: The teacher and students conclude that water molecules flow from the region of high potential (B) to the region of low potential (A).

Generalizations: Water flows from a point where the potential is high to the region where the potential is low.

Defining the problem

There is the need to define exactly what the problem is, after realizing that a problem exists. Then proffer a possible solution to the problem. Students can find out and itemize clear definitions using relevant and appropriate words guided by the teacher. The students and the teacher should define the problem realized.

❖ *Analyzing the Problem*

This analysis is a process which involves arrangement of the problem and its component. The learner and the teacher analyze the problem for better understanding and probable method of approach to the solution.

❖ *Data collection and information*

Collection of data as related to the methods designed in line with the available resources is very important in scientific method. Data related to the problem can be collected under the following ways:

- Through observation;
- Through experiments;
- Through literature survey; and
- Through discussion with professionals

It is very expedient to clearly record without any personal bias, the information accessed by the above stated methods of data collection. The place of the teacher here is to help the students organize these collected data related to the stated problem.

❖ *Analyzing the information*

Analysis of information collected develops the scientific attitude among the learners. Collection of information reveals the uniqueness and diversity of the problem and its dimensions. Irrelevant data can be discarded at this point. Skills of classification and objective comparison can be developed by the students at this point with the teacher's guidance.

❖ *Framing Hypothesis*

Hypothesis is a prediction of probable answer to a question. When one formulates a hypothesis, answers are not just picked randomly, but informed guess is made on the basis of existing information on the topic. Hypothesis is stated in a manner that provides an answer to the question in terms of "if — then — will result". The factor related to the "if is the independent variable; it is something you intentionally vary to see the result. This result, which changes with a change in the independent variable, is therefore known as the dependent variable.

❖ *Verification of the Hypothesis*

Evaluation of the hypothesis is essential to finding out the appropriate one that is most likely to be correct out of many tentative solutions that are proposed. Data collected through

repeated experiments are analyzed and tested using relevant statistical instruments in an empirical research and most appropriate hypothesis selected. Some of the hypothesis could be discarded when there is lack of validity and experimental proof. This step inculcates in the learner the art of experimentation and making decision based on obvious facts.

❖ *Draw a Conclusion*

On the basis of your results, decide if your hypothesis was right. Present this as a conclusion of your experiment, and state if it allows you to accept the hypothesis with which you began. If there is anything you feel can be modified or added to study the topic further, suggest that

❖ *Finding the solution*

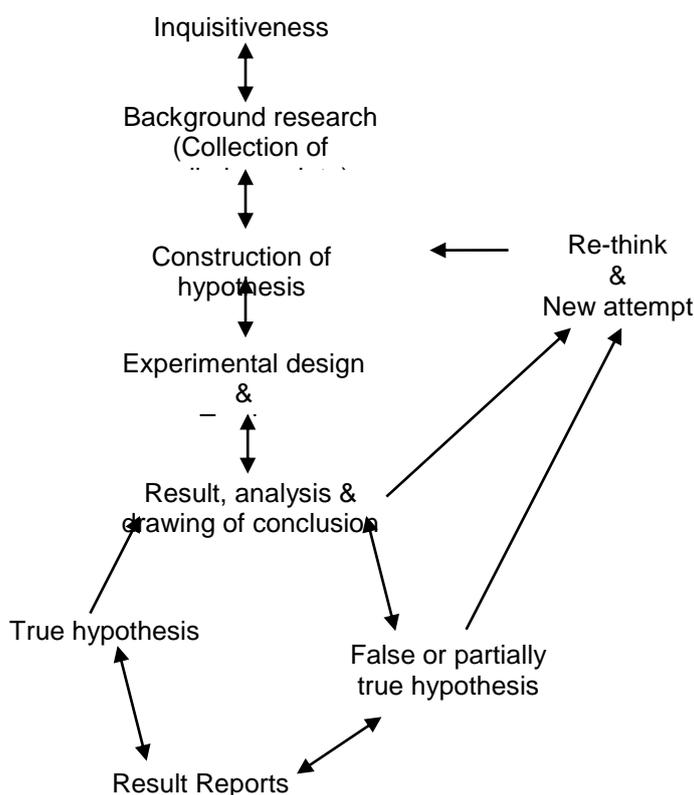
A valid hypothesis selected must be tested under different conditions again and again and if it is consistent, it becomes the final solution to the problem and it can be accepted as a result. These activities make the learner self-reliant and develop his/her decision-making and problem-solving skills scientifically.

❖ *Application of the solutions in the life situations*

The accepted results in scientific method are usually generalized due to processes. The generalized results can be utilized whenever the situations are alike. The learner can apply the same or similar type of methods for problem solving.

The overview of the scientific method can be summarized explicitly in the following flow chart.

Figure 2: Flow Chart on Scientific Method



MEASURING TEACHING PERFORMANCE

Measurement refers to a systematic assignment of numerical values or attributes of an object according to given rules. The implication is that it enables one to collect quantitative information about attributes of an object. For instance, length and width are attributes of a classroom and height and intelligence are attributes of a human being. We can measure the length and width of a classroom, the height of the tallest child in the class or the intelligence quotient (IQ) of the most intelligent child in the class. To be able to measure attributes that are tangible and visible we can use physical instruments such as tape or ruler. Those attributes that are neither tangible nor visible can only be indirectly measured by inferring or making deductions from manifestations of certain behaviour or characteristics ascribed to them. These attributes are referred to as constructs.

To measure a construct, the characteristics associated with are described by a behavioural term. For instance, we can describe language aptitude as ability to speak fluently, write and pronounce correctly in a given language. Similarly, teaching seen as a construct can include among other things, ability to organize and communicate fluently. These abilities can be put down as test items or a set of questions or statements to which participants are examined. For example, if a test in Biology contains 50 items of two marks each, a student's test in Biology aptitude will be represented by the score he makes in the test or score board. Thus the scores give quantitative information about the existence of certain attributes or constructs in a learner.

In Nigeria performance measurement systems in education have not documented real differences among educators in their roles, strengths, weaknesses, or overall effectiveness in improving students learning. As education shifts toward a more performance-focused culture improving the measurement of teachers and principal effectiveness is a critical step. With accurate, reliable and meaningful information about teachers' performance we will be able to better differentiate between "effective" and "ineffective" teachers. Accurate and complete measurement will enable better decisions about future recruitment, professional development, career paths, pay, retention and dismissal.

Let us beam our searchlight on how information should be gathered, assembled, measured and used, both as part of an institution's reward system and to improve teaching performance.

Measuring Performance Elements

It is common knowledge that content expertise, although necessary, does not guarantee effective teaching. Every institution must be able to design and deliver instructional experiences in such a way that there is some assurance that learning will occur when learners engage the activity, The subject matter must be presented in a way that thrills the learners' interest and encourages them to learn. Similarly, the course design and implementation must provide learners with meaningful feedback on their progress in mastering the material.

Furthermore, teachers handle myriad routine tasks involved in managing a course. Laboratory supplies must be ordered and inventories maintained, arrangements for guest lecturers must be made, library materials must be arranged and coordinated, drop/add slips and later grades must be turned in on time, and so on. Thus effective teaching has components such that teachers must interact with learners in a way that (1) provides opportunities for them to learn; (2) creates conditions that support and facilitate learning and (3) uses techniques and methods that create an environment that is learner-friendly.

Arreola, Theall and Aleamoni (2003) propounded five basic skills necessary for effective teaching, viz:

- Content expertise ;
- Instructional design skills;
- Instructional delivery skills;
- Instructional assessment skills; and
- Course management skills

When the total "act" of teaching is defined in terms of these 5 broad components, it becomes clear that the evaluation of teaching cannot be accomplished by using a single measurement tool or by using it on the judgment on one administrator or peer committee who (or other) sources should provide information on the performance of specific elements of teaching in each identified environment as well as how that information should be weighted. In this example, input from students' counts for 25 percent, from peers 45 percent from Head of department, 20 percent and from person evaluated, 10 percent. The "X's" indicate the appropriate performance elements for which each source should provide information; cells highlighted in gray indicate that no data are to be gathered.

Table 1: Example of Data Sources and Weight

Performance Components	Source of Measurement Data			
	Students (25%)	Peers (45%)	Head of Department (20%)	Self (10%)
Content expertise	////	X	////	X
Instructional design	X	X	////	X
Instructional delivery	X	X	////	X
Instructional assessment	X	X	X	X
Course management	////////	////	X	X

CONCLUSION

In this paper, the writers have attempted to discuss what teaching is, its purpose, methods of teaching science and measurement of teaching performance. They have also provided a model with some 5 performance components of content expertise, instructional design skills, instructional delivery skills, instructional assessment skills and course management skills to stake holders with a view to providing an unbiased and balanced assessment of teachers' teaching performance. It is hoped that with these put in place, we can effectively improve in our teaching performance.

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