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Opinion

Development of Science Process Skills among Nigerian Secondary School Science Students and Pupils: An Opinion

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Science process skills (SPS) are skills that occur naturally and spontaneously in our minds as we think individually, collectively and logically about how the world or nature works. Science exposes the knowledge about how the world works. It is this scientific knowledge that builds up scientific character which modern science teachings tries to nurture in the learner. Consequently, SPS are transferable skills needed to undertake meaningful scientific enquiry. This paper highlighted the different science process skills and how some could be developed as we learn science in school. Some advantages and disadvantages were discussed and conclusion drawn.

Key words: Science, Development, Skills, Basic, Integrated.

INTRODUCTION

Learning science from cradle to adulthood begins with the development of science process skills (SPS). This is because science process skills serves as instrument that encourages the learner to perform the kinds of tasks that would lead him/her to reflective thinking and discovery knowledge. It builds up a scientific character which modern science teaching tries to nurture in the learner. Scientists make progress by using scientific method, which is a process of checking conclusions against nature. The development of science process skills (SPS) in students and pupils provide essential components for the development and sustenance of the general goals of education (Gbamanja, 2002).

Science process skills (SPS) occur naturally and spontaneously in most of our individual minds as we think. However, the process of logically breaking down the steps in our thinking about the world; and how to answer our questions either consciously or unconsciously about how the world works involved the use of science process skills (Malhi, 2017). In other words, science process skills are not just useful in sciences alone but in any situation, that requires critical thinking. It forms a basic repertoire of the individual`s general problem-solving skills for life once they are fully developed in the learner (Multisya, Rotich and Rotich, 2013). Generally, scientists work by testing ideas with evidence through scientific method which involved the effective use of science process skills.

The American Association for Advancement of science (AAAS), the National Association for Research in Science Teaching (NARST) and Nigerian Educational Research and Development Council (NERDC) have over the years strongly advocated the development of science process skills (SPS) which guarantees a paradigm shift from knowledge-based teaching and learning to activity-based teaching and learning (Ango, 2002; NARST, 2011; Yumusak, 2016; Vittiand Torres, 2006;).

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In Nigeria, the seemingly lacking provision of educational experience with sufficient details in theoretical and practical or experimental work for students can only be enhanced with the development of adequate science process skills (Ango, 2002). Science process skills among Nigerian secondary school students and pupils seemed to be poorly developed considering the fact that not many a student is exposed to science practical activities at the afore-mentioned levels. There is urgent need to nip it in the bod by encouraging science teachers and students to participate actively in science related activities that would boast the development of science process skills. The traditional or conventional “nature- corner” found prevailing and predominantly too in primary school classrooms in Nigeria, and used to serve as “laboratory” do not seem to serve adequately its purpose. In realization of this also, Kenya through Strengthening Mathematics and Science Education (SMASE) project, adopted the ASEI (an acronym for Activity, Student, Experiment and Improvisation) approach to the teaching and learning of science in school (Mutisya, Rotich and Rotich, 2013). The approach, indeed, simplified the learning of science, excited and activated students’ knowledge and developed their senses of responsibility. In this approach, the learner is encouraged to behave matured in the performance of science inquiry tasks. These tasks involved the use of science process skills.

SCIENCE PROCESS SKILLS (SPS) DEFINED

Science process skills have been defined by many science educationalists (Al-Rabaani, 2014; Gbamanja, 2002; Karamustafaoglu, 2011; Malhi, 2017; Maneerat, 2016; Onwioduokit, 2013; Vittiand Torres, 2006) as inquiry skills used by scientists in their scientific investigations. They are skills that help the learner build up competence in searching for knowledge and information in the field of sciences through scientific method sustenance and arousal of interest in future science-based pursuits. Science Process Skills (SPS) are skills which provide frameworks on how scientists work, think and studies problem seeking for solution in a scientific manner. Specifically, Onwioduokit (2013), defined science process skills (SPS) as skills needed to undertake meaningful scientific enquiry. Yumusak (2016), defined SPS as transferable skills that are applicable to many sciences and reflects the behaviour of scientists. These skills facilitate the learning of science, ensures active students’ participation, have students develop the sense of undertaking responsibility in their own learning, increase the permanence of learning, having students acquire research ways and methods by ensuring their thoughts and behaviours like a scientist. SPS are the building blocks of critical thinking and inquiry in science (Raj and Devi, 2014). Science process skills are special skills and ways of investigation that require: planning course of actions, carrying out activities, collecting data, organizing and interpreting data; and reaching conclusion (Vitti and Torres, 2006). Therefore, SPS is very critical for implementation of inquiry-based teaching.

Gbamanja (2002), observed that SPS formed the basis for building the Nigerian primary school science curriculum. The idea is that once the skills have been developed in the child, he or she lives with the attitudes for life. Science process skills are therefore, special skills that simplify the learning of science, activate or make students become very committed to their learning or studies, and as well develop the students’ sense of responsibility to take charge of their own learning, increases permanency of learning and research methods (Karamustafaoglu, 2011). Accordingly, science process skills are classified broadly into two (2) categories;

i. Basic Science Process Skills (BSPS), and
ii. Integrated Science Process Skills (ISPS).

However, science process skills are inseparable in practice from the conceptual understanding that is involved in learning and in applying science (Malhi, 2017). Classroom studies on scientific reasoning have centered on the basic and integrated science process skills over the past decades; and many researchers have focused their attention on these skills (Brotherton andPreece, 1995; Germann and Aram, 1996; Harlen, 1999; cited in Karamustafaoglu (2011). Basic Process Skills (BSPS) are: observing, classifying, measuring, communicating, inferring and predicting. Whereas, the Integrated Basic Process Skills (IBPS) include: identifying and defining variables, collecting and transforming data, constructing tables of data and graphs, describing relationship between variables, interpreting data, manipulating materials, recording data, formulating hypotheses, designing investigations, drawing conclusions and generalizing. The integrated science process skills (ISPS) are the terminal skills for solving problems or doing science experiments. Accordingly, Karamustafoaglu (2011) observed that the ability to carry out ISPS is akin to hypothetico-deductive reasoning. However, SPS are generally the thinking skills that we use to get information, think on the problems and formulate the results. There are also the skills that scientists use in their studies to understand and develop the information cognitively. These skills are appropriate for all science fields, and they reflect on the correct behaviour of scientists while they are solving a problem and planning an experiment. They also constitute the essence of the thinking and research within science (NARST, 2011; Raj and Davis, 2014; Yumusak, 2016).

It is more important for science students to learn how to apply science from science process skills than learning merely reality, concepts, generalizations, theories and laws in science lessons. Consequently, it becomes necessary for them to pick up the habit of science process skills which are considered to efficient in learning and teaching; and perhaps engage themselves in significant places of teaching programmes in the country. For instance, Science Advancement Process Approach (SAPA) developed by the American Association for the Advancement of Science between 1963 and 1974 focused specifically on elementary and high school science curriculum (Preece and Brotherton, 1997) cited in Karamustafaoglu (2011).

At research based science laboratories, the development of science process skills enables students to construct and solve problems, engage in critical thinking, deciding and finding answers to their curiosity, rather than having them to memorize the concepts (Gbamanja, 2002). Science process skills construct the framework of research based laboratory applications. With the research based laboratory activities, students are able to learn meaningfully, use science process skills and familiarizing themselves with the process of how they can construct the information they gathered from science lessons. In order for the research based science labs to be impressive, then, effective laboratory environment should be developed (Al-Rabaani, 2014; Mutisya, Rotich and Rotich, 2013; Zeidan and Jayosi,2015; Yumusak, 2016).

Ango (2002) have argued that, within the context of Nigerian culture and schools, practical work under the guidance of competent teachers with scientific equipment and procedures are vital aspects of scientific training. She argued that all school science instruction should include practical work as a substantial proportion of instructional program. This is because the benefits of practical work are many, it engenders not only skills which are appropriate for scientific inquiry, but also inculcates attitude and conceptual perspectives which are necessary for skilled scientific inquiry. She contended that practical work is important for Nigerian children because so many do come from home backgrounds in which a scientific view point and empirical experimentation are simply not part of their cultural heritage.

The concept of the spiral curriculum adopted in Nigeria education system, provides an appropriate guide for the teaching and studying of process skills in science. Appropriate selection of science process skills can be used or taught and studied in the early years of primary school. They young students can be given opportunity to observe, handle things and explore the environment (Ango, 2002). The basic learning which pupils achieve from these initial experiences can be used as basis for building a more extensive understanding of science process skills in the later years of primary and secondary school. Therefore, Basic Science Process Skills (BSPS) are foundational skills for the development of more complex integrated skills employed more often at higher levels of secondary and tertiary education.

THE BASIC SCIENCE PROCESS SKILLS (BSPS)

These skills include the following:

i. Observation: Observation involves all the senses and no matter what discipline one is in; he or she needs to be able to observe the details of situation, object or a rapport. Therefore, observation process is a very crucial requirement in science teaching and learning. Observation skills may include the use of senses of seeing, hearing, feelings, touching and smelling. Observation results constitute primary experience or a primary source which is a major ingredient in science learning. The ability to make good observations is also essential to the development of other science process skills. The simplest observations, made using only the senses, are called **qualitative observations.** However, observation that involve a number or quantity are said to be **quantitative observations** (Vitti and Torres, 2006). Quantitative observations give more precise information than our senses alone. Good, productive observations are detailed and accurately written or drawn descriptions which students need to be prompted with to produce as elaborate descriptions. For example, if something is changing, students should be prompted to include before, during and after appearances in their observations. Where possible, students should be encouraged to name what is being observed.

Development of observation skill: Observing qualities can demonstrated by using the five (5) senses, using words to describe what is seen, felt, heard, smelled, and (if appropriate) tasted. Noticing details in objects, breaking things into parts or different components, name and describe the parts, draw what the learner see and label parts of the drawing. For instance, when pupils are blind folded and instructed to use their hands, ears, nostrils and tongues to distinguish between coins and plastics, tasty food or fruits, perfumes and different sounds of objects respectively. They are using other senses than sight in observing the differences. The ability to identify characteristic changes, compare objects and sequence of events depicts observational skill.

ii. Communication: This is the second of the basic science process skills that goes hand in hand with observation. Students have to communicate in order to share their observations with someone else. The communication must be clear and effective if the other person is to understand the information. One of the keys to effective communication is to use so-called **"referents"**. That is, references to items that the other person is already familiar with. For example, we often describe colours using "referents" like; sky blue, green grass, yellow lemon, black charcoal, etc. to depict particular shades of blue, green, yellow or black. The idea is to communicate using descriptive words for which both people share a common understanding. Without referents, we assume to open door to misunderstandings. For instance, if we just say hot or rough, our audience might have a different idea of how hot or how rough. Similarly, describing size of objects could be either larger or smaller than any size of shoes, shirts, cap, etc.

Generally, communication takes the form of talking, listening, writing, reading, drawing, or by using facial or bodily structures. Teachers should help students know how to communicate their needs, feelings and ideas. Teachers should provide opportunities for such communication to be possible. Communication is a skill that must be developed in students. During communication exercise, the students should communicate among themselves or with the teacher their problems, doubts or arguments regarding procedures. At the end of the exercise, discussions will bring out what each individuals or groups of students found out and whether these findings compare favourably with other finding.

Development of communication skill: Communication qualities are demonstrated by ways involved in the process of receiving, spreading and sharing information and ideas in class and other social activities. Communication is expressed through speaking, listening or writing to express ideas or meanings. It involves using and explaining the meaning of symbols, using charts, graphs and tables to present information, positing questions clearly, reporting, experiments to enable others to repeat the experiment, recording information from investigations, drawing and making notes, etc. the ability to translate information received into other forms skill. For instance, students or pupils may be asked to describe or present information about objects seen in classroom or elsewhere, and record information obtained from such objects. Again, the teacher may engage the students/pupils to share their different ideas on what it takes to cook any meal of one's choice.

iii. **Measurement:** This is the determination of that degree to which the objects have those properties. It is just a special case of observing and communicating. When we measure some property, we compare the property to a defined referent called "unit". A measurement statement contains two parts, a **number** to tell us "how much" or "how many", and a **name** for the unit to tell us how much of what? The use of the number makes a measurement a quantitative observation. Measures in weights, distances, areas, volumes and time are important in all spheres of life; especially, in the study and application of scientific knowledge (Vitti and Torres, 2006). Measurement gives us a better description of the item under consideration.

Development of measurement skill: The essence of measurement is to obtain more accurate observations. Therefore, the ability to identify the measurement required, specify the instrument to be used, compare the measurement with the specific instrument, add up the total measurement for the purpose of determining the accuracy is a demonstration of measurement skills. For instance, when the pupils or students are able to;

(i) Count and compare quantity of items in different groups
(ii) Recognize the pattern from a table of numbers.
(iii) Use numbers to record phenomena e.g. like in an electric fan regulator; 0 = stop, 1 = slow; 2 = fast; 3 = faster; 4 = fastest; to reflect the speed of oscillation.
(iv) Compare objects using numbers e.g. (i) 60 seconds = 1 minutes (ii) 2 persons = 1 bicycle (iii) 4 persons = 1 car.
(v) Using tools correctly e.g. (i) using ruler to measure length of a rod (ii) using thermometer to measure temp of water.
(vi) Choosing and using standard unit.
(vii) Comparing time, distance, area and volume with relevant units. Etc. e.g. comparing volume of contents in different dimensions of container.

For instance, teacher may engage the pupils in an activity to find out if two (2) apples weigh the same as one (1) mango fruit. This would facilitate the development of measuring skill in the learner.

iv. **Classification:** This is the ability to be able to sort objects or phenomenon into groups or order, based on observation or measurement or even both. Grouping objects or events is a way of imposing order based on similarities, differences and interrelationships (Vitti and Torres, 2006). This is an important step towards a better understanding of the different objects and events in the world. Students can be serially ordered according to height, size, calories per serving meals, shapes, etc. the ability to classify or group correctly requires careful observation of similarities or distinguishing characteristics. Through the knowledge of classification, scientists have been able to give specific names to specific objects.

In fact, classification makes taxonomy easier. Taxonomy is the science of arrangement of objects or things so as to give them specific names. Classification attempts to arrange the great variety of things, objects or events into organized and logical categories. Important for classification are structure, function, development and evolutionary history. However, there are several different methods of classification. Perhaps, the simplest method is serial ordering into rank order based on some specific property.

Nevertheless, two (2) other methods of classification are "**binary classification**" and "**multistage classification**",(Vitti and Torres,2006). In a binary classification, a set of objects is simply divided into two (2) subsets on the basis of whether each object has or does not have a particular property, e.g.

i. Vertebrate and invertebrate animals
ii. Organic and inorganic compounds
iii. Soluble and insoluble salts.
iv. Alcoholic and non-alcoholic drinks, etc.

A multi-state classification is constructed by performing consecutive binary classifications on a set of objects and them on each of the ensuring subsets to form layers or stages. It is completed when each of the objects in the original set has been separated into a category by itself. For example, the classification of some local animals using physical and/or behavioral similarities and differences can be made with ease. Also, the classification of organic compounds into the different homologues of hydrocarbon compounds (Alkane, Alkene, Alkyne), carboxylic acids (Cyclic and Heterocyclic), amides, amines etc.

Development of classification skill: Classification skill involves the process of grouping or sorting objects according to certain characteristics for a purpose. When there are many items or information available and when these items or information are not organized according to specific characteristics, then, we need to classify them by;
(i) Identify the general characteristics of the items.
(ii) Sort out items of the same characteristics into their respective groups.
(iii) Identify other characteristics.
(iv) Repeat steps (i) to (iii) until there is only one item in each group.

In doing so, the learner is:
(i) Detecting similarities
(ii) Grouping objects based on certain criterion
(iii) Using other criterion in group objects
(iv) Grouping objects in different ways either in terms of colour, shape, size, smell, texture, height, weight etc.

For instance, the teacher may say that these are all different coloured buttons. Now, I will put them into groups according to their colours – red, blue, green. Now, I will separate from each group container of the buttons with 2 (two) holes and those with four (4) holes. Could you please sort out from within each coloured buttons those with three (3) holes. This would facilitate the development of classification skill in the learner.

v. **Inferences**: Unlike observations, which are direct evidence gathered about an object, inferences are explanations or interpretations that follow from the observations. Inferences link what has been previously experienced (Vitti and Torres, 2006). Consequently, we use our past experiences to help us interpret our observations.

Often times, many different inferences can be made based on the same observation. Inferences may also change as we make additional observations. However, we are generally more confident about our inferences when our observations fit well with our past experiences. Also, we are confident about our inferences when our observations fit well with our past experiences. Also, we are more confident about out inferences as we gather more and more supporting evidence. As teachers, we should advise that when students are trying to make inferences, they will often need to go back and make additional observations in order to become more confident in their inferences. That is simply saying that making additional observations will reinforce our inferences, but sometimes, additional information will cause us to modify or even reject earlier inferences. In science, inferences about how things work are continually constructed, modified, and even rejected based on new observations.

In other words, inferences are derived from hypothesis. To infer may mean to guess, to deduce, to imply, or to conclude based on what has been observed. Inferences, therefore, imply cause- and- effects relationships which forma good basis for scientific thinking. Students should be encouraged to make inferences based on several or adequate evidence otherwise they may make mistakes. For example, seeing one insect with only two (2) wings and inferring that all insects have just a pair of wings may be a wrong inference. Also, inferring that a gas which is colourless and turns lime water milky is carbon (iv) oxide gas (CO_2) may be a wrong inference. Inference should be drawn from specific relevant data.

Development of inferring skill: The qualities of making inferences involved a process of making early conclusions by relating previous experiences with immediate observations (Malhi, 2017; Maneerat, 2016; Yumusak, 2016;). We need to infer possibly to plan actions or make a choice and to analyze the cause of effect of decisions-made. This can be achieved through: (i) observing the situations or circumstances very keenly, (ii) state reason why the situation or circumstances happened, (iii) provide reason for your statement (s), (iv) check if the reasons given are based on the opinions or observation from the situations. If it is based on opinions, state why.

These qualities are depicted when you are:
(i) Using information from observations to make reasonable early conclusions. For instance, one might infer that it's necessary to carry umbrella when the cloud is thick, dark and heavy. This because, it might rain shortly.
(ii) Making various possible interpretations from single observation like for example: emergence of rainbow in a dense cloud might mean that rains would be unstoppable by the next day, week or month.
(iii) Able to identify the limitations of inferences. For instance, one might infer that lagoons all have crocodiles, fishes, snails or crabs.
(iv) Testing the accuracy of inferences through additional observations.

(v) Using inferences as a tool to determine the appropriate additional observations.

For instance, the teacher may ask: what are your assumptions on the concepts we discussed in class? Example, I assume that this creature is an insect because it has 6 (six) legs. What have you seen before that remind you of this?. Why do you think that if I do this or that, something is going to happen? These questions facilitate the development of inferring skill.

vi. **Prediction:** Making predictions is making educated guesses about the outcomes of future events. In other words, in predictions, we are forecasting future observations. The ability to make predictions about future event allows us to successfully interact with the environment around us. Prediction is based on both good observation and inferences made about observed events. Like inferences, predictions are based on both what we observed as well as our past experiences. Indeed, they are the mental models that we have built up from those experiences. So, predictions are not just guesses. Predictions based on our inferences or hypotheses about events give us a way to test those hypotheses or inferences. Then if the prediction turns out to be correct, we would have greater confidence in our inference or hypothesis. This is the basis for which scientists carry out most of their scientific processes of inquiry or investigations.

Development of predicting skill: Predicting is a process of forecasting events based on observations and previous experiences or certain pattern of reliable data. We predict simply when accuracy is not essential in: (i) reducing the number of choice, (ii) planning, (iii) considering choices.
However, we carryout predictions by:

- Observing conscientiously in order to gather data
- Identifying the pattern of the data
- Making suitable predictions based on the pattern or past experiences.

These quantities are exhibited when one is:

(i) Using previous or present evidence to state incoming events. For instance, students or pupils may be asked to ascertain the presence of harmattan weather or predict when harmattan weather sets in.
(ii) Able to differentiate between prediction and guessing. e. g. unhappy person frown showing disapproval or when wrinkle one's brow in disapproval or thought. However, a cheerful person is an indication of happiness.
(iii) Using patterns of data explicitly to make projections.
(iv) Able to determine the outcomes from an action.
(v) Being cautious in making assumption about a certain pattern of data beyond the evidence at hand.
(vi) Extrapolating and inserting data as a tool to predict. e.g. (i) to predict scores from plotted graphs. (ii) to predict numbers arithmetically or geometrically in consecutive progressions of: 2,6,8,10…. 1,3,5,7,9… 1,3,5,7,11…
(vii) Posing questions such as what is going to happen if I do this? Example, if one wing of a bird is removed, would it fly again? How will we find out what will happen? What are we going to do to find out what happens? Again, if 5(five) cubes of sugar dissolved easily in a glass of water, would 10(ten) cubes as well dissolve with ease in the same glass of water? All these type of questions facilitate the development of predicting skill in learners/students.

THE INTEGRATED SCIENCE PROCESS SKILLS (ISPS)

As mentioned earlier, the following science process skills; manipulation, experimentation, controlling variables, hypothesizing, prediction etc, are often referred to as integrated science process skills because of its use in combination with other science process skills unwittingly. Perhaps, for relatively higher order thinking processes and complex activities that characterize advanced level students, they are often used combined with BSPS in school activity. They are:

1. **Manipulations:** This skill requires the use of manual dexterity to facilitate active participation from the learners in a learning task. Basically, it involved students exercising their individual ability to manoeuvre apparatus, equipment or tools to obtain data with ease. The manoeuvrable ability exercised by students in practical science lessons is a demonstration of manipulative skill. The ability to improvise and engage the students to source improvised materials within their locality can enhance the development of these skills. Conceptions of contemporary best practice of teaching and learning of science emphasized that students should be involved in the study process through manipulation of equipment and objects, as well as through active participation in any scientific activity pertinent to a given situation in an effective guided study. The skill to manipulate or handle breakables, poisonous, dangerous or expensive equipment can save a lot of students from accidents, waste, and even accidental death. For instance, when students are encouraged to mount and clamp burette by themselves before titration exercise would facilitate the skill of manipulation. The same applies to pipetting and dropping of indicators before the titration.

2. **Controlling variables:** The ability to see patterns from the keeping of one scientific variable constant, while varying the others to obtain consistent changes in experiment depicts the skill of controlling variables**.** A variable is an event, happening, phenomenon or anything that can change and affect the results of an investigation. If anyone wants to produce the same type of quality of product, or the same type of results, the numerous variables that may be involved must be controlled and kept

constant. The entire process of science and scientific experiments deals very much with manipulation of variables, so as to reach or uncover specific concepts. In science experiments, control experiments are set up to identify and control variables that may affect results. Skills of controlling any variable can assist the learner identify patterns and remain focused on control over variables in solving problem situations affecting his or her life. Example, preparation of saturated solution salts required keeping the volume of solvent constant, while varying others. For example, the ability of the science students to regulate the intensity of heat with Bunsen burner flame kept constant while stirring the solution as sugar dissolves show a display of skill of controlling variables. Interestingly, it is used in combination with manipulative skill to achieve better results. Science students should be regularly encouraged and exposed to such activities in the laboratory for the enhancement and development of these skills.

3. **Experimentation:** The ability of a learner to get involved in scientific investigations through scientific methods to obtain results is called experimentation. A scientific knowledge is only accepted when relevant experimentation have been conducted and verified. Therefore, experiment is carried out to investigate the correctness of what the scientists have found or discovered. Experiment involved the scientific method of testing hypotheses which have been formulated based on observations. This attitudinal skill must be nurtured in the students if they must become better future scientists. Undoubtedly, when one is faced with a problem, the reflective mind always designs investigative procedures for solving the problem at hand.

Development of experimental skill: The teacher may ask students to put small salts or sugar in waster and find out if it dissolved. Then, repeat the exercise with few pieces of dry bones. Check if the bones will dissolve in the same quantity of water. Alternatively, if one is engaged in any activity that would warrant the asking of questions such as: I wonder what will happen if I do this or that?, I predict that something like this will happen. What do I have to do in order to find out if i am right or wrong?. What materials do I need?. What steps do I take (procedure)?. How will I know if I am wrong or right? How will I measure my success or failure? If not, why not? All these questions enhance the development of experimental skill in the learner.

4. **Hypothesizing:** Hypothesis is a tentative answer to a problem. It is a guess or an assumption which will be altered or verified upon investigations. However, hypothesis is different from a prediction in the sense that a prediction has much more elements of certainty which are usually based on available evidence than hypothesis. For example, when every little is known about the cause of a particular event or happening, one may hypothesize or guess what the possible cause could be. Science teachers are therefore, encouraged to lead students to make tentative intelligent guesses which can later be investigated.

This is by extension, another way of formulating hypothesis. Example, it might not rain today because the sun is up and brighter than yesterday. Also, a prolong passage of carbon(iv)oxide into limewater would lead to disappearance of milky precipitate formed much earlier and when the solution is heated, white precipitate reappears. This statement of hypothesis can be verified through experiment for confirmation.

5. **Interpreting data:** The ability to read, make meaning and draw valued statements from obtained data is called interpretation. Data collected or gathered during investigations needed to be interpreted in concrete terms, so that reasonable conclusions and generalizations could be made. Interpretation could involve averages, percentages, graphical representation or even more sophisticated statistics which could assist one to arrive at a reasonable conclusion. Interpretation of data leads us to reasonable conclusions and generalization which would subsequently result in predictions of further experiments. As science teachers, we should assist students in development of interpretative skill from recorded data of purposeful observations in order to arrive at concepts, theories, or principles. This is the way science works. Science teachers should engage students in activities that would require the development of interpretive skill. The plotting of curve in graphs and extrapolating points traced to specific marks can be properly understood through interpretation. Scores obtained from data can best be understood through interpretation to meaning. Taking the temperature of classroom at intervals would reveal the climatic condition of the classroom for learning each day of week.

6. **Formulating models:** A model is a physical representation of explanation that sums up or portrays an observation made before. These models are used to predict what could happen in another set of similar observations or circumstances. Evolution of new evidence could challenge the various facets of the model, and a revision of the model may be added to accommodate the new observation.

Concrete models facilitate the formation of mental models and concepts. Models make concepts clearer and increase the retention rate in the learner (Al-Rafaani, 2014; Gbamanja, 2002; Maneerat, 2016).

7. **Making operational definitions**: Operational definitions form the basis upon which investigations at hand may be capitalized. The definition is not necessarily

a lengthy description, but may be a concise and valid communication showing what the thing is. Operational definitions are basically devised to describe a situation for which no former definitions exist at the time. For example, in space science discovery, operational definition such as UFO (Unidentified flying objects) is a terminology used as operational definition for claims by certain people in different parts of the world as unknown flying objects in space. So far, little or nothing has actually been known about these objects. The assurance of whether they exist or where they come from is probably very slim or uncertain until research reveals proper identity of those objects.

Consequently, making an operational definition is very similar to mental models of a **black-box theory**. The black-box is a model defined operationally as a process not yet understood but predictions about it yielding positive results when applied accurately is certain. However, the processes involved cannot be fully explained yet. For instance, much of the earlier investigation into the process of photosynthesis was a black-box type of research until it became fully and clearly explained through chemical reactions.

8. **Raising questions:** It is a known fact that to solve any problem, the investigator or problem- solver need to ask questions. Therefore, to raise questions is a basic skill which grows from observation. Analysis criticism will lead to questioning which may further lead to clarification and understanding. Consequently, learner must be trained not be only passive listeners but active participants in questioning how, when and why things happen, or why certain objects are what they really are:

9. **Counting numbers:** This skill involves the use of discrete numbers in association with units of measure such as 3 bags, 10 apples, 25 books, etc. it involves addition, subtraction, multiplication, division, etc. it is taught in mathematics and practiced in other related sciences for precision in observations and other scientific activities. Numbers organized discretely places magnitude and value to objects. It helps in elucidating facts and figures.

10. **Organization:** Science is characterized as being systematic because of its organized, special approach to investigation and problem solving. Guruge (1977) in Ango (2002), defines organization as a social process which is designed to ensure cooperation, participation and intervention of others in the effective achievement of a given determined objective. Accordingly, the skill of organization as a teaching process which uses school laboratory experiences for science students is summarized into three (3) phases or dimensions of classroom organization as presented below:

i. Getting students involved (i.e. controlling, disruptive behaviorand regulating students' movement in the classroom).
ii. Organizing thinking tasks (i.e. organizing methods by which learning tasks are selected and implemented).
iii. Organizing students thinking process (i.e. cognitive level thinking encouraged in laboratory and the kind of freedom students have to explore ideas).

These constitute part of the educology of science education, that is, as knowledge about a set of teaching skills which are effective in the teaching of science(Ango,2002). The findings revealed that students who experienced frequent use of organizational skills by their teachers achieved higher levels academically in their Biology practical test.

ADVANTAGES OF SCIENCE PROCESS SKILLS APPROACH

1. It develops skills in the learner which he or she could use in solving everyday problem.
2. It is activity-oriented, learner-centered and encourages maximum student participation in the learning activities.
3. It is motivating and increases students interest in their activities
4. Students tend to develop the scientific method of thinking in the learning process.
5. It facilitates concept formation emanating from primary experiences which the learner will encounter in the skills acquisition process.
6. It also encourages the development of skills which are the general attributes of scientists which students must emulate.

DISADVANTAGES OF SCIENCE PROCESS SKILL APPROACH

1. Other non-science disciplines do not seem to benefit much from this approach since it is scientifically oriented.
2. The planning of the activities to facilitate skill developing among students could be time consuming and expensive in terms of material resources required.

CONCLUSION

A skill is cleverness at doing something, resulting from either practice or natural ability. Scientific skills or science process skills are skills needed to undertake meaningful scientific enquiry (Onwioduokit, 2013).

Process skills of science are basic and critical of science teachers (Aktamis and Ergin, 2008; Feyzioglu, Dermirdag, Akyildiz and Altun, 2012; Al-Rafaani, 2014; Maneerat, 2016; Malhi, 2017; Zeidan and Jayosis, 2015). The processes of doing science are the science process skills which scientists used in everyday inquiry and discovery activities. It requires guided study by teachers of science and of educology of science education. Educology is knowledge about education and the educology of science education is knowledge about the process of teaching and studying science in schools, colleges and universities (Ango, 2002).

Expertise in science process skills is a basic and integral part of having effective science teaching skills. The development of science process skills in schools involved various skills that must be imparted and exhibited by our science students in all facets of learning if we really want learning to be more concrete and meaningful. Teachers should focus more on teaching skills, facts, concepts, theories, laws, etc. in school to encourage the students through scientific investigations.

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