



Skill Acquisition and Values for Quality Physics Education: An Imperative for Sustainable National Development

Fasanya A. Gabriel

Department of Science Education,

Faculty of Education,

Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria

E-mail: fasanya@ksu.edu.ng

Abstract

The purpose of this paper was to review skill acquisition and values for quality physics education in Nigeria. Research in physics education at secondary and tertiary levels in recent years has focused more on concept learning than on skills and values development. Values development has received the least attention. This paper therefore, focused on the review of skill acquisition and values for quality physics education. The main policy of physics education in Nigeria is to raise the quality so as to make the recipients of the system technologically oriented, useful to themselves and their society. To achieve this, the paper discussed skill acquisition through practical activities, physics process skills, challenges of practical skill acquisition and development of values. The paper concluded that the state of quality physics education for sustainable development in Nigeria is poor and this calls for emphasizes on skills acquisition through physics practical activities to change the situation for better.

Key Words: Skill Acquisition, Quality, Physics Education

Introduction

The need for quality physics education cannot be overemphasized. It is the umbrella for a host of activities that are designed to improve the quality of inputs, process and outputs for sustainable development. Physics is a discipline that can aid development of any nation. The subject plays important roles in spearheading technological advancement, promoting national wealth, improving health, and accelerating industrialization. Among the sciences, physics is considered a fundamental subject. It equips learners with systematic thinking and supplies the theories necessary for understanding the mechanics of how the things mankind relies on work. Physics provides students with analytical, problem solving and quantitative skills which are relevant for other sciences. Physics prepares students to synthesize and analyze data and to present their findings in understandable formats. The link between physics and other sciences is profound. It is the prerequisite for admission to study other related disciplines such as engineering, geology, medicine, among others.

All technologies are hung to physics because it emphasizes on addressing phenomena involving the interaction of matter and energy. This interaction is necessary for the technological needs

of the changing society (Atadoga, 2010). Physics is widely applied in medicine. For example, medical applications such as imaging techniques, that is, X-

rays, Computer Topography (CT) scanning, ultrasound echo techniques, Magnetic Resonance Imaging (MRI) techniques, and diagnostic patient screening techniques are based on acquisition of physics laws and principles (Freeman, 2012). Currently, a wide variety of treatment techniques made possible by the discovery of radioactivity and other high frequency radiations. The unraveling of the DNA structure and the subsequent genome project require a significant input from physics techniques. Continuing research into challenges posed by diseases such as cancer, Ebola, and HIV/AIDS, will require the development of high precision equipment employing physics principles. The current fixation with information communication technologies (ICTs) could not have been possible without the discovery of the transistor. Computers, mobile phones and their attendant spin-off technologies show the indispensability of physics. Electromagnetism is vital in the generation of electricity, mobile phone communication, optical and satellite communication, portable electronics, radar

perception, X-ray crystallography, to mention but a few (Musasia, Abacha & Biyoyo, 2012).

Physics education refers to both the methods currently used to teach physics and pedagogical research that seeks to improve those methods. Physics education is an important sub-field within science education with focus on the teaching and learning of the subject at secondary and tertiary level, as well as concerned with physics teacher preparation and development. Physics education contributes to sustainable national development through scientific investigation of the physical world as necessary step to finding sustainable solutions to economic problems (Montalbano, 2017).

However, physics education has been undergoing crisis despite its numerous applications in human and national development. Enrolment in physics course at all levels of education is low in Nigeria. Many reasons have been attributed to this: inadequate preparation, weak mathematics background, inadequate teacher qualification as well as possession of below standard pedagogical content knowledge (Semela, 2010). Many students considered physics difficult, abstract and theoretical in nature. Interest in high school physics is decreasing, learning motivation is declining and examination results are getting worse as reported by WAEC chief examiner (2017). In addition to that, many school settings allot little time for physics compared to English language and mathematics, which are also important subjects.

The low enrolment in secondary school physics in Nigeria has been attributed to a shortage of inspirational and well-trained physics teachers, inadequate laboratory facilities and the accompanying limited exposure to practical instruction (Fasanya, 2017). Most physics teachers are mainly trained in theoretical contents aspects. Training in conducting school type science experiments is completely ignored in many teacher training institutions in Nigeria. Effectiveness of teaching physics should be judged by the kind of practical activities that teachers and students engage in, as reported by Oyoo (2004). The consequence is that most physics teachers lack the skills for effective guiding of learners in conducting laboratory.

A big challenge to the attainment of quality physics education in Nigeria is the absence of qualified physics teacher to teach the subject. For physics education to perform its function, there is

the need for qualified professional physics teacher to teach physics at all levels of education system. Research in physics education at secondary and tertiary levels in recent years has focused more on concept learning or understanding than on skills and values development. The conventional way of presenting physics to students often stresses concepts and their relationships, while physics laboratory practical activity emphasizes on skill development. In developed countries, cognizant of the crucial role of science and technology in national development is the trust of physics education. Like scientific literacy, sustainable development is laden not only on concepts but also on skills and values such as the development of human potential, moral, cultural and gender sensitivity, participatory democracy, collaboration, unity and peace.

Skills Acquisition through Practical Activities.

According to Musasia, Abacha and Biyoyo (2012) skill acquisition is considered as engaging learner in observing or manipulating real or virtual objects and materials. It is a mechanism by which materials and equipment are carefully and critically brought together to persuade physics learners about the veracity and validity of the scientific world view. This implies that practical activities enhance students' experience, understanding, skills and make them enjoying science. Practical activities enable students to think and act in a scientific manner. The scientific method should then be emphasized. Practical activities induce scientific attitudes, develops problem-solving skills and improve conceptual understanding. Practical activities in physics help develop students' familiarity with apparatus, instruments and equipment that aid creativity. The observations made and results obtained are then used to gain understanding of physics concepts. Science process skills, necessary for the world of work are systematically developed. Practical activities create motivation and interest for learning physics. Students tend to learn better in activity based subjects where they can manipulate equipment and apparatus to gain insight in the content (Millar, 1998).

However, the reality on ground is that most experiments carried out in Nigeria secondary schools are sterile, un-illuminating exercise whose purpose is often lost on the learners. In most secondary schools in Nigeria, practical work is ill-



conceived, confused and unproductive. Demonstrations are usually done by the teachers who often miss the point of the demonstration. There is usually limited planning and formulation of hypotheses, mostly done by the teachers. In most cases the experiments are derived from mostly irrelevant cultural settings with the attendant equipment disasters. This article acknowledges the great role that well-planned and delivered practical activity in physics can play in influencing students learning of physics in Nigeria secondary schools. For this to happen, practical activity has to form the central part of classroom learning of physics. Deliberate effort has to be made to attract and retain students into the physics class by appealing to curiosity raising element and discovery component of practical activity in the subject (Masasia, Abacha & Biyoyo, 2012).

A sustainable development principle is the development of human potential. Sustainability plays a central role in the present and future of human societies and it has become an unavoidable issue in physics education. Therefore, the goal of sustainability by using physics education should be a primary issue in education (Wals, 2012). According to Nwankwo and Okafor (2017) sustainable development connotes development that meet the needs of the present without compromising the ability of the future generations to meet their needs. They stress further that sustainable development can only be achieved by teaching physics creatively, that is, an ability to generate multiple and unique solutions to a problem. This could only be achieved through scientific skills and values development. In order to make physics education more responsive, meaningful and functional to the recipients and the society at large, there is the need to re-focus attention on the acquisition scientific skills and values which would lead to critical thinking, problem solving and being ICT literate so that Nigeria citizens can be empowered, through relevant science, particularly, physics education (Nwankwo & Okafor, 2017).

Teaching students about science means more than scientific knowledge. There are three dimensions of science that are all important. The first one is the content of science. That is, the basic concepts and our scientific knowledge. This forms the dimension of science that most people first think about and it is certainly very important. The second dimension, in addition to science knowledge are

processes of doing science and scientific attitudes. The processes of doing science are the science process skills that scientists use in the process of doing science. Since science is about asking questions (curiosity) and finding answers to questions, these are actually the same skills we all use in our daily lives as we try to figure out everyday questions. When students are taught how to use these skills in science, particularly, physics, we are equally teaching them skills that they will use in the future for sustainable development.

The third dimension of science focuses on the characteristic attitudes and dispositions of science. These include such things as being curious and imaginative, as well as being enthusiastic about asking questions and solving problems. Another desirable scientific attitude is respect for the methods and values of science. These scientific methods and values include; seeking to answer questions using some kind of rechecking data and understanding that scientific knowledge and theories change over time as more information is gathered.

In promoting physics education and encouraging students to have a career in physics, acquisition of physics process skills is important. The American Association for the Advancement of Science (AAAS) classified the science process skills into two groups: basic science process; observing, communicating, classifying, measuring, inferring and predicting. The second group is integrated science process skills which include: identifying, questioning, controlling variables, hypothesizing, defining operationally, formulating, modelling, designing experiment and interpreting data as pointed out by Okafor (2018). This paper therefore, focused on the acquisition of some of these skills through physics practical activities. The goals of skills development include, to:

1. develop skills for scientific inquiry (Interpersonal skills).
2. develop ability to think scientifically, critically, and creatively, and solve physics-related problems individually or collaboratively (Thinking skills).
3. understand language of science and communicate ideas and views on physics-related issues (Communicating skills).
4. make inference decisions and judgments on physics-related issues (Inferring skills).



However, strategies for skills acquisition vary. For instance, Parisi and Kimlin (2010) used the environment outside the school laboratory to develop science process skills in a student experiment on electromagnetic radiation and its interaction with the physical environment. The amount of solar ultraviolet radiation and in tree shade is measured at different times of the day and compared with changes in illumination levels and temperature. In addition to that, student investigations, project-based learning approach and undergraduate theses can also be used to develop science process skills. Science process skills in physics students cannot be over-emphasized as it is a clear evident in the objectives of the physics curriculum and the proponents of process-based approach uphold the teaching of physics process-skills and advocate for the skills to be developed through experimenting (Abungu, Okere & Wachanga, 2014). According to Okafor (2018), skills acquisition in physics entails activities which students carry out in scientific investigations so as to effectively acquire scientific knowledge for creativity. This was further stressed by Opara (cited in Okafor, 2018) that the importance of teaching science process skills is to promote physics students' ability to describe objects and events, ask questions, construct explanations, test those explanations against current scientific phenomena and communicate their ideas to others.

The need to include physics education in secondary school curriculum is to enable students develop scientific knowledge, skills and positive attitudes towards science and technology, which is key to sustainable national development. This can only be achieved when physics, which is an activity-oriented subject provides physics students with an opportunity through practical activity, to interact with science process skills that can be applied to solve problems in everyday life (Okafor, 2018). Therefore, successfully integrating physics practical activities with classroom lessons and field investigations will make learning experiences richer and more meaningful to students. Students will learn the skills of science as well as science contents. Under such atmosphere, students will be actively engaged with the science they are learning and this will arouse their interest in science, particularly, physics.

The emphasis on physics process-based activities in physics lessons cannot be over-emphasized, as this is clearly evident in the

objectives and instructional programs in physics at Senior Secondary School Level, as pointed out by Okafor (2018). This is also supported by Abungu, Okere and Wachanga (2014) that the proponents of physics process-based approach uphold the teaching of physics process skills and advocate for the development of the skills through practical activities. The physics practical test is designed to develop the three aspects of students' intellectual domains, namely: cognitive, affective and psychomotor. This is the reason, physics students, according to the West African Secondary School Certificate Examination (WASSCE) and National Examination Council (NECO) curricula are assessed or evaluated on practical activities in their final examinations.

However, studies have shown that these practical skills should have been introduced to students at early stage of learning physics. Njoku and Atanga (2011) reported that the late introduction of training in the psychomotor skills of physics students may attribute to their poor performance in the subject. The belief, according to them was that students may have problems in acquiring these practical skills in a short period to write the final examination. In the study of Macbeth (1974), manipulative skills for early grade child is more important than the later grade child because the skills will develop with the child. In the study of Musasia, Abacha and Biyoyo (2012), it was reported that if practical activities are carried out in the right manner from the early secondary school period, critical thinking skills can be attained. The implication of this is that, since science process skills in physics influence students' performance in external examinations such as WAEC or NECO, physics students should be exposed to practical activities right from SS1. Aside promoting the acquisition of the physics process skills, practical activities in physics facilitate the necessary learning environments such as active participation, integration to life and meaningful learning (Karamustafaoglu, 2011).

The Profile of Physics Process Skills

Research and technology began when human being started to observe and ask: what, how, why, where of the nature. Various forms of questions arose due to curiosity nature of man. Curiosity is associated with objects or phenomena that occur around or even about themselves. To satisfy the human curiosity, man has been trying to



understand the changes going around him and has been constantly receiving a great number of impressions through his various senses such as hearing, sight, smell, taste, and touch. Based on the observation, man began to classify objects. Grouping objects was based on shape, size, colour, nature, and usability. These processes were done through series of experiments performed with systematic steps. The experimental activities subsequently led to the birth of variety of technologies (Joshi, 2008).

The science of physics is a growing, changing body of knowledge about the way in which nature behaves. Physics is not an armchair activity. Real progress was made only centuries later, when it was finally realized that the key to scientific knowledge lay in observation and experiment, combined with logic and reason. Of course, the formulation of ideas in physics involves certain amount of just plain thinking, but when the final analysis is made, the crucial questions can only be answered in the laboratory (Marion, 1979).

The basic physics process skills are what people do when they do science. They use their senses to observe objects and events and they look for patterns in those observations. They classify to form new concepts by searching for similarities and differences. Orally and in writing, they communicate what they know and what they are able to do. To quantify descriptions of objects and events, they measure. They infer explanations and willingly change their inferences as new information becomes available. They predict possible outcomes before they are actually observed. According to Karamustafaoglu (2011), physics process skills can be divided into two groups: basic and integrated process skills. The basic process skills include: observing, asking questions, classifying, measuring, inferring and predicting. The integrated process skills include: identifying, and defining variables, interpreting data, manipulating materials, recording data, formulating hypotheses, create data tables and graph, designing investigations making inferences and generalization. Nowadays, the most discussed issues in science education is the assessment of science process skills. Non-inclusion of these skills in the teaching and learning of physics may pose danger to the technological development of a nation (Harlen, 2013).

Challenges of Practical Skill Acquisition

Several factors have been identified as challenges to skills acquisition among secondary school students in Nigeria. Few of them are discussed briefly in this paper.

1. **Teacher's Quality:** It is commonly said that no education can rise above its teachers. Training in handling physics practical lessons has been ineffective in most secondary schools in Nigeria. Adededeji and Bamidele (cited in Okoro & Agugum, 2017) pointed out that the alarming rate of ineffectiveness of teachers (inputs) in the profession of teaching has led to substandard students (products). Most teachers of physics in Nigerian secondary schools are mainly trained in theoretical contents aspects. Most of them are void of content and pedagogical knowledge. Many graduates of physics nowadays lack the skills of handling secondary school practical work, and therefore, the attendant advantages of performing practical work are lost in the learners.

2. **Inadequate Laboratory Facilities:** Many secondary schools in Nigeria lack laboratory facilities that facilitate practical skill acquisition. Some secondary schools do not even have science laboratory. This is sometimes caused due to inadequate funding. For effective practical skill acquisition, physics laboratory should be stocked with modern facilities that would facilitate students' understanding of physics concepts.

3. **Students' Academic Ability:** Difficulties related to skills acquisition in physics have been associated to the ability level of students as pointed out by Njoku and Atanga (2011).

4. **Limited Exposure of Students to Practical Activities:** The frequent at which practical activities is conducted is another factor that can affect skills acquisition in physics. In many secondary schools in Nigeria, students are exposed to physics practical activities probably once or twice in a term. The limited exposure of students to practical activities may pose problems to them in acquiring these practical skills to write the final examination.

Development of Values

This section examines some selected researches and perspectives on development of skills and values in physics teaching for patterns and trends and posits directions for the physics education community to consider. The values development focuses on attitudes towards science

and its usage to students. These value include: cultural and moral sensitivity, community-based physics teaching, social justice, peace, order and unity, global linkage, gender sensitivity, self-determination, and participatory democracy.

Cultural and Moral Sensitivity: Physics related artifacts, for instant native toys and musical instruments can be brought to class by students. Physics-related cultural practices, such as fishing, can be taken up when appropriate. Moral sensitivity can be demonstrated by discussing values vis-à-vis scientific values.

Community-Based Physics Teaching: This is an approach for community involvement of the physics class. It addresses physics-related community needs and uses physics-based resources.

Principle of Social Justice: This can be actualized with quality physics teaching to the students of low ability level in public schools so that students who are at risk of dropout can be identified and helped through outreached physics programs such as community-based physics projects.

Peace, Order and Unity: To promote peace, order and unity, a physics class can have cooperative learning in group activities and experiments and a classroom climate conducive for learning. Values of responsibility, openness and respect for others can be developed among the students as they work in groups.

Global Linkage: Global linkage or cooperation in physics teaching can take the form of collaboration with scientists through emails, e-group discussion, common laboratory experiments and video conferences with classes in other countries.

Gender Sensitivity: Gender sensitivity, which contributes to social justice, can be promoted with active equal participation of boys and girls in a physics class, as well as in textbooks, encouraging girls to handle electrical and electronic devices and motivating girls to consider a career in physics.

Self-determination and Participatory Democracy: These can be developed in a physics class with group activities, experiments and discussion, inclusion of design of investigations or projects, and use of self-learning modules and internet (Talisayon, 2006).

Conclusion

The roles of physics in human and nation building are obvious. For students to derive optimum values of the subject and acquire the required

employability skills to meet the need of the 21st century scientific development, it is imperative that the subject be taught through practical approach using qualified physics teachers. Therefore, there is the need for assessment of the mode of teaching of physics in Nigerian secondary schools.

Suggestions

Based on the foregoing remarks, the following suggestions were provided.

1. For physics teaching to be appreciated by students, skills acquisition should be emphasized by physics curriculum planners for the purpose of employability skills.
2. There should be a complete review of the mode of physics instruction that will reflect skills acquisition and values.
3. The Federal, State and Local Governments should invest massively on physics education.
4. Teacher's quality should be emphasized. Only qualified and well-trained teachers should be allowed to teach physics in secondary schools.

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