TRANSFORMING PHYSICS EDUCATION IN NIGERIAN SECONDARY SCHOOLS THROUGH QUALITATIVE AND QUANTITATIVE PRACTICAL ACTIVITIES

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Abstract

Transformation is inevitable in every system (our educational system inclusive) that wishes to prosper in volatile, uncertain, complex and ambiguous environment. Strategic management of a change is all about identifying and embedding in every educational system those changes that will ensure the relevance and long-term survival of cultural values and educational system of every society. The focus of this paper is the level of involvement of learners in Nigerian Secondary Schools in physics practical activities- a necessity for true meaning and greater understanding of physics concepts. Physics practical activities, was observed, to be poorly performed in secondary schools in Nigeria. There is, therefore, a need for paradigm change of attitude by every stakeholder of secondary education in Nigeria-students, teachers, parents, curriculum planners, administrators, certificate awarding examination bodies and Government-towards this aspect of teaching and learning of physics. Physics practical activities, just like its classroom teaching, should be included in the secondary school time-table for its weekly performance and should be rated equally with the theory by certificate awarding examination bodies in Nigeria; and efforts geared towards provision of modern and standard, well equipped laboratory in every core-science teaching secondary school in Nigeria.

The word 'transformation' is a synonym to change. Transformation, according to Cambridge Advanced Learner's Dictionary, is a complete change in the appearance or character of something (or someone), especially so that that thing (or person) is improved. New meanings for 'transformation' entered the modern lexicon in the early 1980s when it was extensively used at the launching of "coming out party" for Luciferian Theosophists. Ferguson (1980) defined it as "transformation of consciousness," "a new seeing," "conscious evolution," and a "paradigm change." Transformation was an essential part of the Teilhardian leap from "*individual evolution*" to "*collective evolution*". However, in the early 1990s, transformation came to be associated with the massive plan to overhaul the American educational system.

"Education transformation" was a term nuanced with esoteric meaning-referring not only to the comprehensive "economic, social and cultural health of every citizenry in every society," (Charlottee, 1999) but also, in global education circles, to education in "higher order thinking skills" to facilitate the collective evolution of consciousness (Berit, 1995).

Educational reform experts, it was discovered, were using the term in the same way that the New Age Theosophists were using it. Transformation or radical change is pervasive and inevitable. The impetus to change comes from the environment. By environment we mean internal organizational/systemic environment, but more often, we are referring to external environment. Every system is awash in (or a sub-set of) the environment. Powerful forces in the environment are pressurizing systems/organizations to alter permanently existing structures, policies and practices (Bolman & Deal, 1991). Some of these powerful forces include: globalization; peace; Information and Communication Technology; demographic changes and the like. Transformation is inevitable in systems or organizations that wish to prosper in volatile, uncertain, complex and ambiguous environment. Change is absolutely necessary for the survival of individuals, organizations, systems and societies. This is because the strategic environment, over which we have little or no control, is in a state of constant change and so it is very imperative for us as individuals to identify, plan and execute changes in our organizations and systems appropriately in response to change in the external environment. Educational transformation is about alterations to the purpose, culture, structure and processes of an already existing system of education of a society in response to seen and anticipated changes in the needs of the society as a result of changes in the environment. Strategic management of a change is all about identifying and embedding in every educational system those changes that will ensure the long-term survival of cultural values and educational system of the society concerned.

Change can be thought of as a condition and a process. Change as a condition describes what is happening in the environment, it is part of reality we must accept. Change as a condition may profoundly influence our education, but it takes place externally and humans have little control over it. Change as a process is what we foster internally in response to changes in the environment. It is leadership and management we take to change our organizations or systems. Therefore, unlike changes in the environment, change as a process is ours to influence or manipulate (Sullivan & Harper, 1996). Change can be planned or unplanned; both can be good, both can be bad. It can be tactical or strategic and change can be evolutionary or revolutionary. It can take place gradually within an existing paradigm, or it can be a dramatic shift to an entirely new paradigm. In addition to being gradual, evolutionary change usually is linear, and sequential. The downside of evolutionary change is that it is predictable. Competitors can figure out what a particular organization is doing and predict where it is going.

Revolutionary change is about transforming the organization. The revolution can be small or it can be sweeping. The path of transformational change, while not linear and sequential, can be made predictable to people inside the organization through proper planning and communication. Both evolutionary and revolutionary changes can be legitimate strategic choices under the right environmental conditions.

Physics-The Most Basic and Fundamental Science

Physics, in its modern sense, was founded in the mid-19th century as a synthesis of several older sciences-namely, those of Mechanics, Optics, Acoustics, Electricity, Magnetism, Heat and the Physical Properties of Matter. The synthesis was based in large part on the realization that the different forces of nature are related and are, in fact, interconvertible because they are all different forms of energy. Historically, physics has developed through observation of natural phenomena and derivation of laws which describe these phenomena. Physics is crucial to understanding the world around us, the world inside of us, and the world beyond us. It is the most basic and fundamental science. The scope of physics ranges from particle physics to cosmology. Particle physics studies the smallest particle of which all ordinary matter is made up of (known as sub-nuclear particles). Cosmology, on the other hand, deals with the behavior of material universe in its entirety. It is the study of different forms of energy from which every other thing in the universe originates (The Big-bang Theory).

Physics has been very successful in revealing many of nature's profound secrets and has played key role in the development of many disciplines such as Chemistry, Biology, Medicine and Engineering. It is pivotal to economic, social and cultural development of every nation. Physics is the major agent of transformations witnessed in the world around us in the time past, transformations we are witnessing at the moment and transformations we are going to witness in the future.

Teaching and Learning of Physics – The Practical Reality

Teaching is a social process involving communication and interaction between the teacher and the taught, with a view of improving the standing of the taught in the cognitive, affective and psychomotor areas or a combination of them (Denga, 2005). It is an art of transmission of knowledge, attitudes and skills to an individual or a group of individuals through a well-planned and well-structured instructions, interactions and training for preservation of the knowledge and its applications in the exploration of the environment to bring forth more knowledge, better attitudes and skills and more importantly, make our world a more beautiful place to live-in (Olabimtan, 2012).

Methods of teaching are the systematic techniques adopted by the teachers in the impartation of knowledge attitudes and skills to the learners. Method is a process of establishing and maintaining contact between the pupil and the subject matter, in order

to create in the pupils the right attitude in the subject. Therefore for effective teaching and meaningful learning to take place a teacher must be able to discern the best method to be used for the concept/topic he/she wants to teach, taking into cognizance the nature of the students involved and the lesson's objectives to be accomplished. For sound and qualitative understanding of concepts of physics, all of the following are required:

1. **Excursion or Sight-Seeing:** this important aspect of teaching and learning physics has been neglected for a very long period of time by almost all the Secondary Schools in Nigeria. In fact this is the main reason why parents could not help project good image of physics to their wards. Excursion or Sight-seeing is inculcated in physics education to boost the interest of students in physics and help them appreciate the beauty and see the relevance of physics in their immediate and/or global community. Out of 50 Secondary Schools distributed in four Local Government Areas, namely: Bichi, Dawakin Tofa, Ungongo and Fagge in Kano State used as case study in this report, only 10 have conducted Excursion once in the last five years for their science students. The situation is very worrisome. Physics is seen by the majority of students in Senior Secondary Schools in Nigeria as very difficult (Soyibo, 1986), very remote and abstract (Hussain, 2008). Ajayi (2000) noted that students generally classified the three core science subjects-Biology, Chemistry and Physics-into level of difficulty. He reported that Biology is considered the easiest, followed by Chemistry and Physics being the most difficult. The cause of negative perception of students towards Physics was identified by Adebayo (2008) to include: the fear of the mathematical skills involved, harsh teacher-students' relationship, students' lack of readiness to study, preconceived bad information that Physics is a difficult subject and poor method of teaching. Negative perception and its enumerated causes can be completely tackled by boosting the interest of students in physics through excursion to places where the relevance and applications of physics is generally appreciated and acknowledged. Boosting the interest of students in physics will give the willpower to embrace the subject irrespective of previous beliefs or current challenges.

2. **Theoretical Knowledge:** this is obtained through interaction between a teacher and his/her students in a classroom environment or any other environment conducive for learning. For the desired meaningful physics education, effective physics instruction must be provided. Effective physics instruction is instruction that changes the way students think about physics and physics problem-solving, and causes them to think more like expert-practicing physicists (Hammer, 1997). The teacher's method of teaching, without mincing words, is a major determinant in enhancing effective learning by the students. In spite of the best efforts of teachers, typical students see physics as a boring subject and irrelevant to understanding the world around them. The definitive conclusion is that no matter how "good" the teacher, typical students

in a traditionally taught course are learning by rote, memorizing facts and recipes for problem solving; they are not gaining a true understanding. There is agitation to inculcate the 21st century teaching approaches to physics education in Nigeria. These include: inquiry method, collaborative teaching, demonstration method, guided-discovery method and other child-centered methods.

3. **Practical Physics Activity:** this involves carrying out of an orderly procedure (an experiment) or a set of carefully arranged instructions with the aim of verifying, refuting, or establishing the validity of a hypothesis. In other words, an experiment is used to test existing theories or a new hypothesis in order to support or disprove them (Devine, 2006; Griffith, 2001). However, an experiment may also aim to answer a "what if" question, without a specific expectation about what the experiment will reveal or to confirm prior results. In Physics, Chemistry and Engineering, experiments are a primary component of the scientific method. Typically, experiments in these fields will focus on replication of identical procedures in hopes of producing identical results in each replication; this definitely fosters a greater understanding of the concepts upon which the experiment is directed. According to Olabimtan (2015), the continuous performance of experiments in the laboratory by learners of physics, apart from the fact that it helps in the greater understanding of physics concepts, instills some skills in the students. Some of these skills, amongst others, include:

a. Familiarity with and usage of different apparatus or machines in the laboratory;
b. Precision in measurement through exposure to different measuring equipment;
c. Skills on verification of existing theories for its confirmation or disapproval;
d. Skills about making new discoveries through orderly procedures;
e. Observation skills – which helps in inculcating sense of alertness to changes in the environment for probing (Research and Development skills);
f. Problem identification and problem-solving skills; and,
g. Safety measures and precautions skills.

It is very disheartening that despite the fact that all the skills enumerated above can be acquired through proper conduct of physics practical activity, and that it (physics practical activity) could foster proper understanding of physics concepts as well as ability for its application in the resolution and management of social, economic and environmental problems for the much desired technological advancement and all round development of our nation, this aspect of learning of physics has not been accorded the much expected attention by Physics teachers, Educational planners, Educational administrators and Government (at all levels) in Nigeria.

Out of 50 Senior Secondary Schools in four Local Government Areas of Kano State used as case study, only 20 have structure that could be called a laboratory (the

laboratory is being shared/used for all the core science subjects) while 30 schools had no laboratories. Earlier educational researchers reported that most secondary schools in Nigeria have no Physics laboratory and few that are having are rather ill-equipped while most of the apparatus are obsolete and malfunctioning making reliability of measurement taken with them absolutely unreliable (Soyibo,1986; Ajayi, 2007). Also out of the 50 schools, 5 conduct physics practical activities on weekly basis, 10 conduct practical activities once in every month while the remaining 35 Schools conduct practical activities in physics in the final class when Certificate Examinations (WAEC and NECO) are approaching. Ajayi (2008) while assessing the level of students' involvement in practical activities in physics laboratories in Nigeria concluded that only 23.23% of schools did allow their students to carry out practical activities in Physics. The practical activities on various aspects of physics are inadequately carried out in schools (Jegede & Adebayo, 2013). The neglect of practical component of teaching and learning of physics contradicts the objectives of Physics education in senior secondary schools as stated in the curriculum (1985) and the National Policy on Education (2004).

Certainly no effective teaching and meaningful learning can take place in physics without necessary learning materials, equipment and more importantly, practical activities. Many of the methods that have worked so well for advancing physics research also improve physics education. Considerable evidence have shown that methods that include basing teaching practices and principles on research and data rather than on tradition or anecdote; using new technology tools effectively; and disseminating and copying proven results, give students true meaning and greater understanding of physics concepts. Classes using research-based teaching practices/methods have shown dramatic increases in retention of information.

Ratings of Different Aspects of Physics in Nigerian Secondary Schools by Certificate's Awarding Bodies

In Nigeria two independent bodies are responsible for the award of Senior Secondary School Certificate Examination (SSCE), they are: West African Examination Council (WAEC) and National Examination Council (NECO). Students are examined on their theoretical and practical knowledge of concepts of physics and whatever score obtained in these two aspects form the basis of their total score in physics. The different aspects of physics together with their ratings are analyzed in the table below:

Table 1: Ratings of Physics in WASSCE and NECSSCE by WAEC and NECO

S/No	Components/Instruments of Examination in Physics	Nature	Max. Marks Obtainable		Weighted Percentage	
			WEAC	NECO	WAEC	NECO
1.	Objective Questions	Theory	50	50	31.250%	29.412%

2.	Theoretical Questions	Theory	60	60	37.500%	35.294%
3.	Practical Questions	Practical Activity	50	60	31.250%	35.294%
	TOTAL MARKS		160	170	100%	100%

The Continuous Assessment (CA) scores submitted by Schools to these Examination Bodies (WAEC and NECO) also form an insignificant part of every candidate final score, about 5-10%. This CA scores submitted by Schools for physics students have no component of practical activity in physics because many schools fake CA scores to meet the deadline for submission of grades while many other schools inflate CA grades to favour their students since they are added to WAEC and NECO final results which defeats the purpose of CA. The purpose of the table above is to analyze the percentage of attention given to physics practical activity by the Examination bodies since, in Nigeria, more marks to an aspect of a subject is an indication of greater attention to that aspect of the subject.

Table 1 reveals that in WASSCE, 31.25% of the Senior Secondary Certificate Examination conducted by WAEC is based on Practical Activity in Physics while 68.75% (approximately 69%) is based on the theoretical knowledge of students. The implication of this is that without any practical knowledge in physics, the maximum marks obtainable by a candidate in physics are 69 out of 100. 69 marks according to the Grading System of WAEC is a B (one mark less than 70 which attracts A). Also in NECSSCE, 35.29% of the Senior Secondary Certificate Examination conducted by NECO is based on Practical Activity in Physics while 64.71% (approximated to 65%) is based on theory. This makes the maximum mark available to students in physics with no practical knowledge at all to be 65marks. 65 marks is also a 'B' in NECO Grading System. Without mincing words, allocation of (or apportioning) more marks to practical activities in physics implies drawing greater attention to those aspects of learning of physics.

The Way Forward: Transforming Physics Education in Nigeria

Appreciable increase in number of students with good and sound knowledge of concepts of physics is a must for every nation that wants to advance technologically. The technological advancement of a nation is hinge on its level of Research and Development. The levels of Research and Development are the differentiators between developed and the developing nations. Improving the practical component of physics education, aside the fact that it will bring true meaning and greater understanding of physics, will help in developing and nurturing of inherent deposit of innovation and creativity every physics student is endowed with, and hence the zeal for the much needed Research and Development for the advancement of our nation. Physics Practical

Activity on various concepts of physics is inadequately carried out in our Senior Secondary Schools in Nigeria. For transformation of physics education in Nigeria, it is imperative to alter some parts of the existing system of physics education in response to the new needs and change in the environment since it is beyond our control.

Conclusion

Physics practical activities are poorly performed in our Senior Secondary Schools in Nigeria and this is a major barrier to true meaning and greater understanding of concepts in physics. Physics practical activities instill, in every learner, skills that are beneficial, in immeasurable ways, to Research and Development, which is the basis of Science and Technology. Science and Technology is a major differentiator between the developed and the developing nations of the world. Transformation of physics education through improving the qualitative and quantitative of practical activities in our secondary schools will help: to boost, promote and popularize the image, public perception, interest and greater understanding in physics; and, more importantly, help in the advancement of our technology and project us towards being a developed nation.

Recommendations

A few suggestions are offered below for the transformation of physics education bearing in mind that the list is in exhaustive:

i. Deserved attention should be given to excursion, an integral part of physics education in Nigeria. In fact it should be made compulsory (may be once or twice per term) in our Senior Secondary Schools in Nigeria to boost, promote and popularize the image, public perception, understanding and interest in physics;

ii. Just like physics classroom teaching, physics practical activity should be included in the Senior Secondary Schools time-table in Nigeria. All secondary schools should be mandated to conduct practical activities, at least once or twice on weekly basis;

iii. Since both theoretical knowledge through classroom activities and practical laboratory activities are vital for sound understanding of physics, external Examination Bodies (WAEC and NECO) should be made to rate the two aspects equally in the Senior Secondary Certificate Examination, (Theory 50marks and Practical 50marks);

iv. The Management of every Core-Science teaching Senior Secondary Schools (both public and private) in Nigeria should be mandated to make provision for a modern, standard and well-structured laboratory with necessary and appropriate facilities;

v. Every laboratory should be sufficiently and adequately stocked with modern and contemporary apparatus, equipment and machines for physics practical activity in our Secondary Schools;

vi. Every Physics laboratory should be provided with alternate source of energy/power for operations of the equipment for unhindered access of the students to the equipment for practical activities;

vii. Adequate and effective measure should be put in place for proper and continuous maintenance of laboratory apparatus, equipment and machines and/or repairs by Administrators of education in every Secondary School in Nigeria

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