Developing and Assessing Science and Technology Process Skills (STPSs) in Nigerian Universal Basic Education Environment

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Abstract

The paper examines the centrality of Science and Technology Process Skills (STPSs) in Universal Basic Education (UBE) learning environment in Nigeria. UBE programme was implemented in Nigeria to ascertain the Millennium Development Goals (MDGs) in order to make education free and compulsory to all school age children up to junior secondary school level. It also looked at the position of the STPS, structure for measuring STPS at the UBE school levels. Since Science and Technology (ST) teachers could only transfer the skills in them to students, basic STPS that are necessary for complete teacher education were also outlined. Therefore, the teaching and learning of science, technology and mathematics at both the primary and junior secondary schools should not end at seeing the cognitive final outcome but also developing and assessing the process skills that have been acquired by the students. Science and technology curricula need to be modified to engender opportunities for students to demonstrate their science and technology process skills during teaching, learning and assessment processes.

Keywords : *Science process skills, Nigeria, education*

Introduction

Education is the wheel on which all nations developmental programme ride. Educational dynamism causes changes and brings daily rethinking of how to make it more relevant in positively building a self reliance nation. If education is given the right focus, it will not only be a source of growth for all sectors of economy but also would foster current waves of global technological development to be achieved in a country. All nations of the world realise this fact by coming together to fashion out means and how education would be at reach of every child by organising conferences and submits that would usher in positive changes in governance, economy and technology. Examples of such conferences were World Conference on Education for All (Jomitien, 1990), The E-9 Submit (New Dehli, 1993), Second World Congress on Education and Information (Moscow, 1996), Second International Congress on Technical and Vocational Education (Seoul, 1999), World Science Conference (Budapes, 1999), Education for All (EFA) Forum (Dakar, 2000) among others.

African countries including Nigeria actively participated in these conferences. Obanya (2000) summarised the lessons most African countries learnt from these conferences as awareness raising, capacity building, enlarged partnership and inter-learning. This development therefore, brought a lot of challenges in form of how to integrate education into the overall national development; develop holistic education, prioritize, carry everyone along, sustain capacities, manage resources and develop innovations to proffer solutions to educational problems.

In taking drastic step to implement the Millennium Development Goals (MDGs), Nigerian government launched the Universal Basic Education (UBE) programme in 1999. Its implementation took off in 2005 when government disbursed UBE funds to Universal Basic Education Commission (UBEC) and to each state. The concept of Basic education is not a new move to the Nigerian society for the vision is meant to universalise access to education, enhance equity while focusing on teaching and learning environment (Yoloye, 2004). The goals of UBE include

- Developing in the entire citizenry a strong consciousness for education and strong commitment to its vigorous promotion;
- Provision of free UBE for every Nigerian child of school age;
- Reducing drastically the occurrence of drop-out from formal school system;
- Catering for young persons, their schools as well as other out of school children through appropriate form of complementary approaches to the provision of UBE;
- Ensuring the acquisition of appropriate levels of literacy, manipulative communicative and life skills as well as the ethical, moral and civic values needed for laying a solid foundation for life long living (Federal Government of Nigeria, 2000).

In order attain life skills as stated in UBE goals, the learning of science and technology play important roles especially when appropriate science skills are developed in the learners.

Implementation Guidelines and Challenges of UBE

Based on the white paper on UBE implementation, the following guidelines were giving for its effective take off:

- Pubic enlightenment and social mobilization for community development
- Data collection and analysis
- Planning, monitoring and evaluation
- Teachers' recruitment, education, retraining , and motivation
- Infrastructural facilities
- Enriched curricula
- Textbooks and instructional materials
- Improved funding
- Management of the entire process (FGN, 2000).

Eight key areas could be identified from these guidelines as shown in figure 1 below:

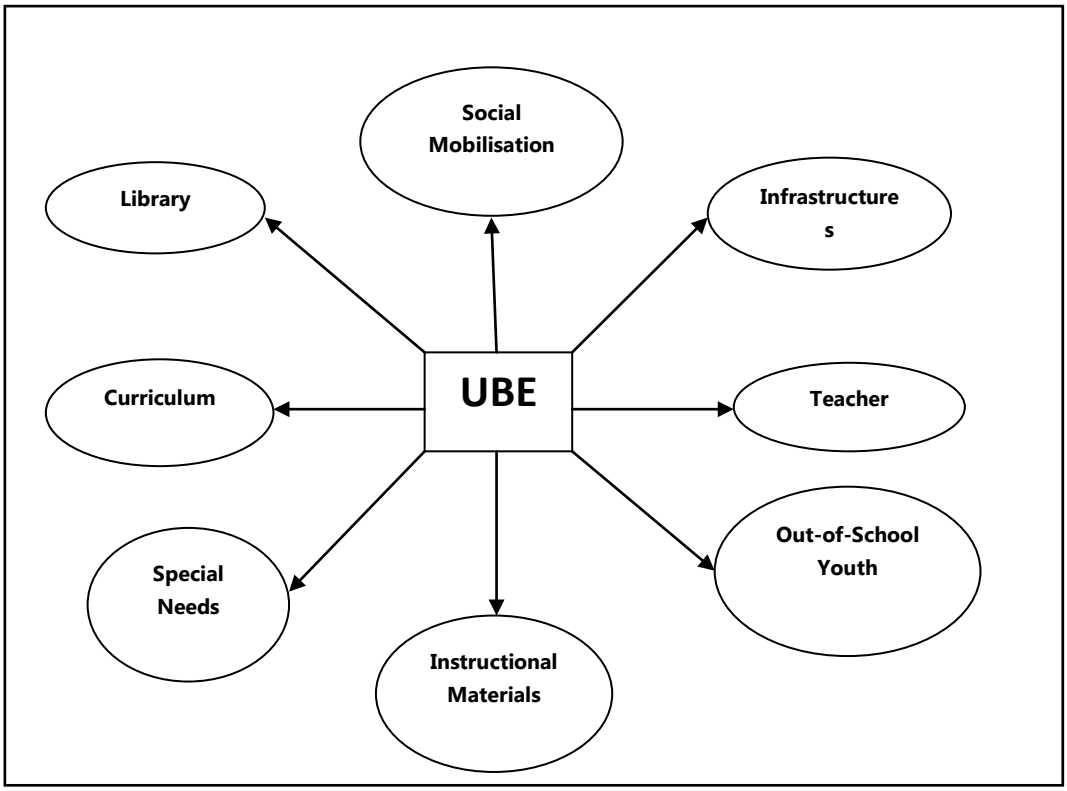

Figure 1: *Key areas of focus of Nigerian Universal Basic Education*

In spite of these guidelines, UBE was faced with a lot challenges in form of funding misuse, inadequate provision and maintenance of infrastructural materials, supervision and monitoring at the UBE centres, daily home-school distance covered by children, inadequate planning, unhealthy rivalry between private and public schools and ineffective science, technology and mathematics teaching/learning in schools. Dike (2000) observed that since UBE is intended to provide free and compulsory education to every Nigerian child of school age, its implementation should not be left in the hands of greedy and corrupt politicians but educators should be allowed to organise, manage, and supervise the programme. UBE also upholds the ideals of National Policy on Education which emphasised that universal basic education, in a variety of forms, depending on needs and possibilities, shall be provided for all citizens; lifelong education shall be the nation's educational policy, educational activities shall be centred on the learner for maximum self-development and self-fulfilment; and efforts should be made to relate education to overall community needs.

STPS Position in UBE Programme

In implementing UBE, education is made free and compulsory from primary to junior secondary school levels in Nigeria. Therefore, the introduction of basic education which spans through nine (9) years of lower basic (Primaries 1 to 3), middle basic (Primaries 4 to 6) and upper basic (JSS1 – 3). Nigerian science and technology curriculum at junior secondary were reformed to reflect the UBE

ideas. For instance the previous integrated science becomes Basic science, Introductory Technology is now Basic Technology and Mathematics also. Basic sic science has four themes: You and your Environment, Living and Non-living things, Science and Development and You and Energy. All the STM themes were geared towards skills acquisition in Nigerian learners. UBE Curriculum contains Arts and Languages, Social Studies and Civic Education, Vocational subjects, Mathematics, Science and Technology. Figure 2 shows that ST and mathematics directly linked to technological development through skill acquisitions when process skills are emphasised in learning and teaching.

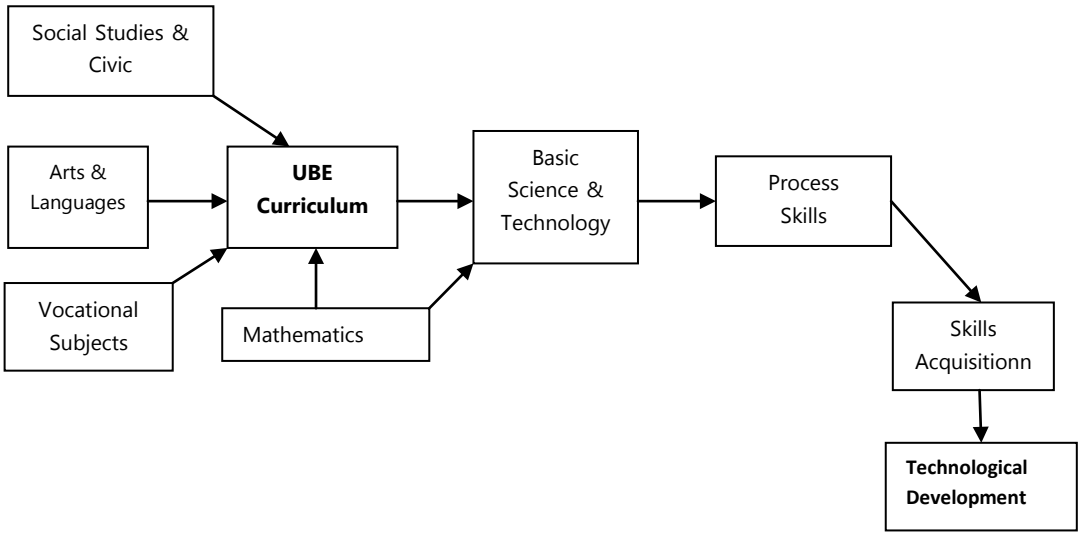

Figure 2: *Relationship of UBE Curriculum, STPS and Technological Development*

STM Process Skills at Basic Education Levels

There are questions science asks in terms of what, which, why, how... When teaching science and technology and mathematics in order to achieve UBE goals, teachers laying more emphasis on questions of "what" and "which" should be minimised because they encourage rote learning in learners and do not measure high level attainment. Process skills involve answering "how" questions which enable learners to explain deeper understanding of scientific processes. ST teaching involves integrating process skills acquisition and not just knowledge attainment. ST and teaching about STM are more than just acquiring scientific and technological knowledge but also ability to do science (Ivowi, 2006). There are three dimensions of science that are important viz (i) content of science, the basic concepts and scientific knowledge (ii) process of doing and (iii) scientific attitudes. The processes of doing science are the science process skills that scientists use in the process of doing science. When we teach science students to use these skills in science, we are also teaching them skills that they would use in the nearest future. Process skills develop favourable scientific attitudes and disposition in learners. These include being curious and imaginative including enthusiasm about asking questions. Therefore, these skills affect the personal, social, and global lives of individuals. The STMPS are fundamental tools to produce and use scientific information, to perform scientific research, and to solve problems. These skills can be

attained through certain science education (Harlen, 1999; Hupert, Lomask & Lazarorcitz, 2002). STPS summarily is how a scientist works, thinks and solve problems and proffer solutions.

At basic education level, the ST process skills include

(i) Defining problem (ii) Estimating (iii) Collecting data (iv) Observing (v) Classifying (vi) Measuring (vii) Presenting data (viii) Table drawing (ix) Graph drawing (x) Predicting (xi) Communicating (explaining results)

At the primary school (lower and middle basic) levels, the STMPS are organizational in nature. These involves

Observing: By using five senses to identify the characteristics of objects and their interactions

Communicating: Object are identified and events are described so that information can be processed

Comparing: Objects and events are viewed in relations to similarities and differences. When comparing known to unknown learners can gain knowledge about the unknown.

Organizing: By systematically compiling, classifying and ordering data learners gain knowledge of principles and laws.

At Junior secondary (upper basic) level, the STMSP are relational in nature and such include experimenting the process by which concrete and abstract ideas are brought together to test or explain a phenomenon. Relational skills are inductive, deductive and hypothetical reasoning. Relational scientific methods consist of five steps:

Identifying the problem: Stating what the investigator wants to find out.

Hypothesis: Proposing a solution

Experiment: Testing one variable at a time to determine its relative effect on another in order to solve a problem or answer the question.

Results: When data are appropriately presented one can easily see the relative effects on one or more variables.

Conclusion: Finding out if there is sufficient evidence from the results to answer the original question. What was discovered by doing the experiment.

These active learning processes are achieved in doing, experimentation, use of hands, thinking, response to enquiry, creative challenges, enquiring, analysing, design exercises initiating innovations and all then are turned to acquisition of skills. The usefulness of these skills would result in ability of learners to assess performance, obtain and interpret results, re-design alternatives and motivation for continued learning.

Tasks for Assessing STPS

ST teachers need to draw questions or tasks which might be used to assess science process skills in students base on scientific skills enumerated above.

Observation: Assessment questions could find out how students are able to

- Use senses to notice specific features
- Identify qualitative and quantitative changes in conditions
- Identify similarities and difference in features
- Classify objects, specimens, organisms using observable properties

Predictions

- Predicting the results for a proposed laboratory test or set up
- Selecting predictions based on previously observed patterns
- Providing rationale for the predictions

Calculations

- Using measurement to determine area, volumes, percentages, ratios etc.
- Determining volume of acids that would neutralise a particular quantity of base.
- Performing statistical analysis of raw data as mean, median, mode, range, standard deviation

Data Presentation

- Preparing an appropriate tables, charts, diagrams, illustrations etc.
- Assessing the presentation of data

Graphing

- Selecting appropriate graph for set of data as line, bar, and pie chart etc
- Identifying the title source dependent and independent variables
- Labelling of axes
- Scaling each axis for a graph
- Preparing a line, bar or pie chart to represent a set of a data
- Spotting the coordinate points and marking them
- Making a best line fit
- Interpreting a graph and making predictions or inferences based on the data on a graph.

Inferences

- Formulating assumptions based on observations
- Differentiate between observations and inferences
- Using observations and inferences to identify testable questions and problems

Involving Process Skills in ST Teacher Education Development

In order to ensure that ST is well structured in the UBE, the issues of ST teacher development in various institutions need to be looked into by inculcating relevant process skills in them. Such skills could include

- Construction of a unit plan utilising the discovery method of instruction for a set of content, skills and / or attitudes for a selected elementary, primary and junior secondary schools
- Environmental maintenance to be conducive to the teaching and learning of ST through appropriate classroom and laboratory management techniques. This would be evaluated during micro-teaching using appropriate use of an evaluation form.
- Demonstration of increased competency in applying and skills in defined strategies and techniques of classroom methodology as revealed through a series of micro-teaching experiences.
- Demonstration of increased STPS in planning, organising and teaching individual of students through participation in a series of planned in-school experiences
- Presentation of a lesson on an assigned topic using a student prepared lesson plan and unit plan.
- Construction of ST instructional modules by utilising the discovery methods of instruction for a given set of content skills or attitudes for appropriate UBE educational levels.
- Planning and using lessons involving technological approaches to meet the diverse needs of the learners in a variety of educational settings after having made a series of observation in ST classrooms
- Listing the careers relating to STPS to be acquired.
- Preparation of a variety of assessment modes consistent with the goals of ST courses to assess students' outcomes, i.e. quizzes, tests, examination.

- The would-be ST teachers should be trained on how to make valid observation, classify objects, measure, make inferences, form prediction, recognise space-time relation and recognise number relations.
- Matching primary process skills with an appropriate description or activity.
- Preparation of a list of safety precautions for primary and junior secondary schools.
- Identification and analysis of specified science, technology and mathematics curriculum improvement projects.

The ST teachers need to undergo a training that will inculcate these skills in them. When they possess them, they would pass on to the ST students who would apply them in the nearest future to proffer solution to life problems.

Instruments for Measuring STPS in Students

When assessing students' overall performance on ST-based subjects, teachers should not based such assessment on the product alone by emphasising the cognitive attainment. The end results might not justify the means, process skills of arriving at the product as shown by each student could be ascertained using appropriate rating system. Teachers could evaluate students' abilities to make and communicate observation, determine whether they demonstrate these skills. Examples of such process skills' ratings tools are

Process Skills in Evaporation: Changing from Liquid to Gas

S/N	DESIRED SKILLS	5	4	3	2	1
1.	Identification and using relevant instruments e.g. measuring cylinder					
2.	Measuring appropriate volume of water					
3.	Transferring water to container					
4.	Drawing the container being used to hold water					
5.	Recording how much water evaporate					
6.	Recognising that water escapes					
7.	Predicting the conditions for evaporation to take place					
8.	Making relevant inference					

Process skills in graphing operations

S/N	DESIRED SKILLS	5	4	3	2	1
1.	Identification of graph sheet.					
2.	Compilation of table					
3.	Choosing appropriate scale					
4.	Drawing of the axes					

5.	Calibration of graph axes based on choice of scales					
6.	Fixing of points					
7.	Joining of points to draw appropriate graph shapes					
8.	Putting title of the graph					
9.	Using graph to answer questions					

Process skills in drawing of isometric cube block

S/N	DESIRED SKILLS	5	4	3	2	1
1.	Familiarity with isometric drawing tools e.g. drawing paper, Tee-square, set square etc.					
2.	Drawing a horizontal line					
3.	Drawing a vertical line at a particular point on the horizontal line					
4.	Measuring required angle using relevant tool					
5.	Marking out required points based on specified measurement					
6.	Completing the block by joining the marked points					

The aforementioned skills were just samples of areas of focus in basic science, basic technology and mathematics. Teachers set students on process skills activities, observe students carrying them out and rate each of them on level of attainment of those skills from a minimum of 1 and maximum of 5. Other science-based teachers could develop skill rating tools relevant to their subject areas.

Conclusion and Recommendations

Achievement of Universal Basic Education goals is hinged on the abilities of STM teachers to develop and assess basic process skills acquired by their students. Therefore, teachers need to re-orientate themselves to lay more emphasis on skills acquisition among students instead of much emphasis on knowledge attainment during classroom and laboratory lessons. Teachers are supposed to facilitate the development and acquisition of appropriate manipulative skills, laboratory management techniques and workshop practices where applicable in students. Since doing science leads to skills acquisition, teachers evaluation of students performance should not be limited to the cognitive domain alone but involve psychomotor where a lot could be achieved through observation and completion of appropriate checklists and rating scales.

The following recommendations are necessary to enhance the level of science and technology process skills in schools' science learning and teaching especially the UBE enabling environment:

1. Learners should be initiated to inculcate the sense of skill acquisition in learning science and technology.
2. Students should be guided to make research activities intended to enhance the level of their STPSs.
3. Science and technology based subjects' curricula should be developed with the mind of improving STPSs of the students.
4. Teachers should derive teaching methods that would assist in developing STPSs in students.
5. Assessment of students in ST subjects should not be based on the knowledge alone but also skills acquire by the students during teaching and learning.
6. Each ST teacher should develop relevant assessment tools (instruments) for assessing skills developed in the students.

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