

## **Innovative and Effective Science Teaching Strategies for Quality Assurance in Nigerian Secondary Schools**

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**Abstract:** This study introduces some new teaching strategies for science classrooms in Nigerian secondary schools to ensure quality in teaching and learning. The purpose of this study is to improve science teaching by combining selected new teaching strategies with traditional teaching methods to improve the quality standard in science classrooms and to enhance students' performance in the basic science subjects. These teaching strategies include student-centred learning; problem based learning, conceptual change teaching, case studies and cooperative learning. The principles of science classroom effectiveness in teaching/learning and improvement of assessment methods using new assessment procedure in the science classrooms is also discussed. Some practical examples were also given as means of improving experimental science teaching quality using cooperative learning and case studies.

**Key words:** Science, new teaching strategies, secondary schools, quality assurance, Nigeria

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### **INTRODUCTION**

One of the aims of secondary education in Nigeria is to contribute to national development through high-level relevant manpower training (Federal Republic of Nigeria, 2004) and science education is viewed as a means of producing scientists needed for national development. Hence, the National Policy on Education (Federal Republic of Nigeria, 2004) states that science education shall emphasize the teaching and learning of science processes and principles. The National Policy on Education (Federal Republic of Nigeria, 2004) also views education as an instrument for National development hence the curriculum content of secondary is meant to be dynamic in order to meet the needs of the larger society.

It has also been observed that the type of curriculum designed for Nigerian secondary schools is the spiral curriculum and the constructivism approach to spiral curriculum provides that children should learn by discovering things for themselves. In his view, opines that the world's declaration of education for all was not simply to make school available to all but to also promote the type of quality education that provides the tools, knowledge, skills, values and attitudes required by human beings to be able to survive. Such quality of education has the capacity for developing the full potentials of learners to live and research in dignity; participate fully in development improve the quality of their lives make informed decisions and to continue to learn. This implies that the curriculum content of the secondary schools

needs to have in them specific skills, knowledge and values to be acquired by its graduates as well as the right attitudes of mind required of them to function in the society in order to live meaningfully and contribute to the development of themselves and the society they live in. In the view of Adikwu, the curricula in Nigeria are outdated hence calls for a review specifically, the science curricula in order to make them relevant. He declared that there is urgent need for curriculum development, especially in the sciences to be in line with the Millennium Development Goals if Nigeria is not to be left behind in the globalization process.

Literatures abound on theories of teaching and learning especially in science classes as every subject has techniques and methods that are unique to its teaching and learning. The teaching and learning of science in an ideal classroom is expected to be done following the processes proposed and used by scientists. Effective use of the strategies by science teachers leads to the acquisition of science process skills/entrepreneurship skills by the students. The Federal Government of Nigeria in the National Policy on education recognized this and spells out clearly that one of the National education goals is the acquisition of appropriate skills, mental, physical and social abilities and competencies that will equip the individual to live in and contribute to the development of the society. Therefore, the main goals of science education shall be to cultivate inquiry, knowing and rational mind for the conduct of a good life and democracy as well as to produce scientists who will

be self-reliant and promote National development (Federal Republic of Nigeria, 2004). The place of science in the development of any nation cannot be over emphasized as the level of development of any nation is now determined by the level of scientific activities being practised by its indigenes.

Some of the teaching strategies that have been recommended for science teachers to inculcate science process skills in their students include demonstration, direct observation, field trip, group research, laboratory activities manipulations, modelling, reading and seminar (Ibe and Nwosu, 2003). These writers advocated that science should be taught through hands-on method approaches where students are placed in problem solving situations and surrounding them with appropriate materials that will enable them process information to solve scientific problems. This view conforms to the recent emphasis of the Federal Ministry of Education on the use of field studies, guided discovery, laboratory techniques and skills coupled with conceptual thinking as major teaching strategies for the implementation of the Senior Secondary School Science Curriculum.

Despite the foregoing recommendations, studies have shown that teachers have consistently stuck to the lecture method of teaching as the major strategy in science classroom teaching (Ibe and Nwosu, 2003). In a study by Ibe and Nwosu (2003) to determine the effect of guided inquiry and demonstration on science process skills acquisition in biology, it was found that the group taught with guided inquiry method performed significantly better than those taught with the demonstration and conventional methods. They therefore recommended that since guided inquiry methods of teaching helps to acquire science process skills which enhance the understanding of science concepts, teachers should adopt the method in the teaching of science.

In Nigeria, many researchers have reported about students' poor performance in secondary school science subjects in external examinations and this has been linked to teachers' poor methods of teaching. As earlier indicated, teachers prefer to use the traditional lecture/expository method instead of engaging in innovative activity-based methods that engage students in hands-on and minds on activities like the discovery concept mapping, laboratory approaches and co-operative learning and this has greatly affected the quality of education in Nigerian secondary schools.

The possibility that teacher educators may share in this practice of use of poor teaching methods could have far-reaching implications in Nigeria's educational system. Most times teachers teach the way they were taught.

Johnson (2004) posited that most teachers were not taught using the inquiry method since they themselves did not have the opportunity to learn science using the inquiry method nor have they conducted scientific inquiries themselves. Osuafor (1999) also ascertained empirically that most science teachers in Nigeria have no knowledge of how to effectively utilize innovative science teaching strategies such as experimentation, project method, concept mapping and field trips/excursion. These findings raise questions about quality of Teacher Education Programmes in Nigeria and how well science teachers are prepared to handle science teaching with current, innovative and effective strategies which will enable the students' to be actively engaged.

### **QUALITY IMPROVEMENT IN SECONDARY EDUCATION**

Quality assurance is a mechanism used to evaluate the efficiency and appropriateness of teaching and learning in secondary schools so as to ensure the delivery of high quality education. It is also a holistic method of identifying and resolving problem within the educational system in order to ensure continuous quality improvement. It can also be described as means of disseminating information regarding the quality of secondary education.

According to Birdsall *et al.* (2006) in the enrolment of students' in schools the challenges of access/quality and quality of teaching/facilities must be resolved if schools are to offer quality education. According to Bateman (2006), quality assurance includes defined standards of achievement, documented procedures for all identified processes, established ways of responding to issues and clear accountability for outcomes. The importance of consistence and continuous quality assurance in secondary education are many. Some of these benefits associated with consistent quality assurance and continuous quality improvement measure in education include:

- The establishment of establish high standards academic excellence which will go long way to enhance the schools reputation and image
- Improved communication across the school system
- Improvement of outcome so that the policies and procedures are constantly revisited through analysis and the delivery of teaching and learning
- Identification of systems strengths and weaknesses, determination of the program effectiveness and tracking of its integrity
- Increase in capacity to secure funding and refinement service delivery

## **QUALITY TEACHING AND EDUCATIONAL EFFECTIVENESS IN NIGERIAN SECONDARY SCHOOLS**

A difficult aspect of quality oversight arises when problems are found in terms of educational effectiveness. That is definitions and broad criteria generally fail to offer sufficient guidance about where to draw the line between what is adequate and what is not. Effectiveness is not one-dimensional but depends on the way that various resources research in combination. Fundamentally, it requires a look at outcomes and what an institution accomplishes. It means questions about whether school graduates are well prepared whether they have both the knowledge and skills that they and society expect as a result of their studies (Chapman and Austin, 2002). According to Bacchus quality of education often means raising the level of academic performance of students usually as measured in test scores in the various subjects which form part of their school curriculum (Bacchus, 1995). In actual fact, teachers are a very vital force in educational effectiveness at classroom instructional level. They are charged with the responsibility of implementing the school curricular and the pedagogical techniques sufficiently as well as show what Creemers (1994) called effective instructional behaviours. However, Lowe and Istance (1989) citing Darling-Hammond and others identified four quite distinct characteristics of what is expected of teachers.

**Teaching as labour:** The activities of teachers should be rationally planned and programmatically organized by administrators with the teacher merely responsible for carrying out the instructional program.

**Teaching as craft:** Teaching is seen in this conception as requiring a repertoire of specialized techniques and as well as mastering the techniques the teacher must acquire general rules for their application.

**Teaching as art:** Based not only on professional knowledge and skills but on a set of personal resources uniquely defined; techniques and their application may be novel, unconventional and unpredictable.

**Teaching as profession:** The teacher needs not only a repertoire of specialized technique but also the ability to exercise judgement about when these techniques should be applied and hence a body of theoretical knowledge (Lowe and Istance, 1989).

If the role of a teacher is as stated above, it now becomes unclear who exactly is a good teacher and

what is expected of him or her (OECD, 1992). However, according to Gbamanja (1991), effective teaching and learning are normally guided by good principles which the teacher must bear in mind as he teaches. These principles are in exhaustive and they have been derived from the characteristics of the learner, the teacher and the learning situation. They assist teachers know the various conditions under which effective learning is likely to take place. Science teachers must be guided by these principles if they want to succeed in their teaching. According to Gbamanja (1991) the principles of effective science teaching given:

**Adequate planning and preparation:** A teacher who plans and prepares well before class is always likely to achieve better results. This includes planning your notes of lessons and preparing appropriate materials for particular lessons.

**Effective assessment tests:** Students have a tendency to achieve in the ways they are tested. If you design your tests to know whether your students have known facts then these students will have the tendency of memorizing facts for your examinations.

**Clearly stated objectives:** Students learn more effectively if they know the objectives and are shown how to achieve them. Science teachers must strive to discuss with their students the objectives for doing various experiments and also discuss the various inquiry processes for solving various problems.

**Students to work in groups:** Students learn from one another. It is therefore necessary to organize your students to work in groups particularly as they work on various tasks in the laboratory.

**Multi-talent approach to teaching:** Holistic teaching achieves better results than fractionated teaching. You must teach for the total person and not just to develop portions of the individual.

**Relevance:** A curriculum that is relevant and meaningful to the learner is more likely to achieve better results. Teachers must put meaning and relevance in their teaching so as to develop interest in the learners.

## **IMPROVING TEACHING METHODS AND TEACHING QUALITY IN SCIENCE CLASSROOMS**

The traditional teaching approach is a Teacher-Centred Teaching Model. According to a survey

in a traditional course, students only listen and they can only retain 26% of the knowledge the teacher presents (King, 2004). Students learn passively and employ surface level processing. They are over-dependent on information selected and provided for them by their lecturers. But it is difficult to abandon the traditional teaching approach completely because Nigeria has a very large population of students; thereby leading to large class sizes. The traditional teaching approach requires fewer teachers and teaches more students. So, it is necessary to improve the traditional teaching approach step by step. The main goals of the improvements to the course are to enable students: to master science and technology principles more deeply, using scientific knowledge; to analyse and solve science-related problems and to develop the ability of independent thinking. Teachers should introduce these new teaching strategies such as student-centred teaching, problem based learning, case studies, conceptual change teaching and group learning to their class to improve the teaching methods and increase their teaching quality. Here, students will not be passive learners but active learners where science/concepts are not viewed as abstract but concrete. Students will understand science when they practise or do the activities necessary to understand science concepts. Each one of these new teaching strategies are discussed in this study.

**Using student-centred teaching:** Chalk and talk is the predominant teaching style in the traditional teaching approach. Student-centred teaching is based on the hypothesis that students benefit by being given the freedom to study and search for solutions based on their personal interests (Hendry *et al.*, 2001). Students are allowed to discuss and research together on the problem, to explore different paths for solutions without pressure in workshop tutorials. The responsibility for learning is with the students (King, 2004). In order to overcome some shortcomings of traditional teaching approaches such as spoon-feeding and over-dependence on the lecturer, student-centred teaching is a useful method to improve traditional course teaching and adapt to the changes and trends in teaching theories and practice. The results of contemporary research in education theory have shown how students learn and how teachers teach students more effectively. This approach can give students flexibility, self-confidence and social skills.

In student-centred teaching, the teacher teaches only what he or she considers important and difficult in the lecture. The responsibility of the teacher is not only to deliver skills and provide a conceptual map of the subject but also to motivate students to be more active, adaptable, confident, creative, cooperative and inductive

in their thinking. The teacher must help students make the transition from passive listeners to active participants, changing from a superficial to a deep learning approach, developing the students' abilities and skills for lifelong learning. We should teach them fishing and not to give them fish. Students need to move from passive to active learning and from dependence to independence.

**Using problem based learning:** Problem Based Learning (PBL) is one of the exciting and powerful educational options that have appeared in the last 30 years. PBL is a learning environment in which the problem drives the learning. PBL begins with tackling a relevant problem that usually covers most of the course knowledge. In PBL the problem may not be solvable but students can learn much by engaging in the process. Students themselves decide what they need to learn by engagement in the problem solving. Of course, lecturers still retain their importance for course learning. But the uncton is changed, switching from transmission of knowledge to a situation where teachers find out common difficulties in the problem solving process and give support via lectures (Woods, 1994). So, PBL is a strategy for encouraging critical thinking, cooperative learning and enhancing problem solving skills through resolving real world problems. The main features of this strategy (PBL) are: relevant problems; creating a need to know; integration of academic and professional knowledge and interactive and cooperative learning (Tang *et al.*, 1997).

**Using case studies:** Case studies are different from PBL. They give real and complete stories with messages and questions and teach through those stories. The case usually has both academic significance and social application (King, 2004). A good case study should be interesting, relevant, motivating, integrating many disciplines and related to the real world. A good case study tells a story is current and relevant, creates empathy is short, requires solving a problem and serves a pedagogical function. Case studies enable students to understand the application of science to real-world problems, to trace commercial innovations of well-known products from conception or an idea in the research laboratory to commercialisation and to realise the influence of science on the environment. We can also use case studies to help students to: build analytical and synthesis skills; develop problem-solving skills, decision-making skills, judgment skills, critical thinking skills and communication skills and learn how to deal with real-life problems.

In a case study, the teacher guides students through the maze of the case discussion by questioning, demonstrating and highlighting the main points or issues.

The students will be given background material related to the case, to read, think about and discuss. Then, the teacher will give a mini-lecture on the background material to explain the relevant knowledge. In a case study, background material and mini-lecture direct students to search for related materials and information to form a concept map relevant to the study. After that students can understand the generation of the problem and determine the methods to solve the case. At the same time, there is an opportunity for teachers to ask students some relevant questions to stimulate their thinking and to enable them to discover for themselves the route to a possible solution or resolution. It is a very useful way to train their academic and critical thinking abilities (King, 2004).

**Using conceptual change teaching:** Many teaching strategies have evolved from the constructivist-teaching mode which includes strategies such as analogy, metaphor, problem-solving, concept mapping, interactive learning and conceptual change teaching. Of these entire strategies, conceptual change teaching seems to be potentially most viable in helping students to change misconceptions to scientifically accepted ones. A misconception occurs when students construct knowledge for themselves, outside the classroom (or even in the classroom) because they sometimes get it wrong and construct misconceptions that don't match those of modern science. In conceptual change teaching, learners' role is taken to be an active role not a passive role and learners construct understanding. Students learn conceptual knowledge (concepts of science) and students' misconceptions are changed due to better understanding of concepts since they actively involved in the learning process.

**Using group learning or teamwork learning approach (cooperative learning):** Cooperative learning emphasizes group research based on a premise that compared with competitive or individualized environments, working in groups leads to improved learning and better attitudes. This learning is most effective in Nigerian schools where science teachers are faced with the challenges of large classes which make the classes impractical. Through collective information, thinking, discussing, reading and studying, students would improve their understanding of many basic concepts and principles of science concepts. Most importantly, students would understand how to apply the knowledge of science. The teachers are still very important in a teamwork learning approach. Their

duties are to ensure laboratory safety, to provide material and equipment for experiments, to assign group leaders, to assist group leaders in answering conceptual and technical questions of students, to supervise group activities, to assess group written assignments and to evaluate each group's laboratory techniques.

In traditional teaching approaches, students do experiments without understanding why they are using the apparatus provided for them or understanding many of the experimental steps since only the teacher gets involve in the activity process. The teamwork learning format has a definite advantage in overcoming this weakness. The teamwork learning laboratory will be more focused on research work and designing laboratory activities and requires more collaboration between students and the development of teamwork. Teamwork learning methods also require students to have more imagination, more planning and to accept more challenging tasks. It places more emphasis on active learning and extra skills development. Before the laboratory session, students need to plan and design the detailed laboratory steps. During the laboratory session, they need to check their plan and design and revise the laboratory project. After the laboratory session, they need to analyse the data and experimental phenomena and write the experiment reports (Hagen, 2000). Encouraging students to become deeply involved in the laboratory research and develop their skills are the main purposes of the new teaching strategy.

#### **IMPROVING EXPERIMENTAL SCIENCE TEACHING USING COOPERATIVE LEARNING OR GROUP LEARNING**

Experimental science helps students to be actively engaged. The laboratory is an ideal environment for both active and cooperative learning (Hass, 2000). Active engagement in laboratory exercises promotes a thorough understanding of the concepts described in lectures. A further enhancement of the laboratory experience can be gained by encouraging students to interact with each other during the discovery process. Experiments or laboratory work are very important for students not only for understanding science concepts knowledge but also for increasing the students' ability to resolve problems.

Many of the traditional experiments can also be improved by using teamwork learning or a group learning approach in which students work collaboratively in the development of methods to obtain, apply and understand

information. The benefits associated with teamwork learning include improving performance on academic tests, improving proficiency in critical reasoning abilities and the acquisition of communication and inter-personal skills (Hagen, 2000). It is planned to implement an active teamwork learning strategy in this organic chemistry laboratory.

In the teamwork learning format, students will be randomly assigned to groups of several members and group membership will be maintained throughout one or two terms. Each week, the teacher will assign one person in each group to serve as group leader. The group leader has five major responsibilities: present pre-laboratory teachings; assign tasks; answer questions; submit group assignments and assess group members. The group members' responsibilities are to carry out the experiments, to contribute to written assignments and to assess the group leader individually. At the end of each experiment, the students will participate in peer assessment. Group members assess the performance of the group leader and the group leader assesses each group member. For each experiment, students will also be required to complete written assignments as a group. Laboratory worksheets will contain five to ten questions related to the theoretical aspects of the experiment, experimental design and setup. These will be collected 1 week after the experiment is completed. Worksheets generally require of time outside of the laboratory to complete. Each group will require one notebook.

#### **IMPROVING EXPERIMENTAL SCIENCE TEACHING USING CASE STUDIES LEARNING APPROACH**

In secondary science classes, each term can be split into blocks and for each block there are the main components of instruction: a qualitative overview to help students understand basic concepts, change misconceptions and represent problem-situations with words, sketches, diagrams and graphs; a quantitative overview, covering the same concepts but now including math. During both overviews for a large number of problem-situations; the students make multiple representations-verbal, pictorial, physical (with motion diagrams and force diagrams), mathematical and translate these in both directions usually moving from verbal to math (conventional) but sometimes from math to verbal so they can invent a problem that is consistent with the starting equation with explicit explanations (of ideas and skills) followed by activities (pencil and paper using a set of active learning problem sheets made) so students could apply what was explained. Students learn

conceptual knowledge (concepts of science), procedural knowledge (problem-solving strategies) and conditional knowledge (about when to use these strategies) outside their science class. The students also do activities (posing various types and levels of challenge) that include case studies in which they must combine ideas and skills from different parts of one block or from different blocks; throughout terms. The logical relationships between ideas are clarified and emphasized, to help students integrate their knowledge into a comprehensive hierarchical structure built around the basic concepts of science and overall the instruction moves in spirals of increasing sophistication with students improving their understanding and retention by using their ideas and skills over an extended time interval and in a variety of contexts. This new strategy of science teaching will improve students' learning greatly since science concepts will no more be seen as been abstract but concrete.

#### **THE IMPROVEMENT OF ASSESSMENT USING THE NEW TEACHING STRATEGY IN SCIENCE CLASSROOMS**

A new teaching strategy needs a new assessment procedure (McDowell, 1995). Assessment methods profoundly influence learning (Norton *et al.*, 2001). In order to encourage active learning and meet the requirements of the new teaching strategy in science classrooms in Nigeria; a combined assessment in any of the science courses is recommended. The final mark will consist of 5 parts: a formal written examination (final examination) which will be worth 50%; test questions which will be worth 20%; assignments which will be worth 10%; laboratory performance and reports which will be worth 10% and a mini-presentation which will be worth 10%.

#### **CONCLUSION**

In this study, researcher has looked at ways to improve science teaching by combining selected new teaching strategies with traditional teaching methods to improve the quality standard in science classrooms and to enhance students' performance in the basic science subjects. These teaching strategies include student-centred learning; problem based learning, conceptual change teaching, case studies and cooperative learning. The principles of science classroom effectiveness in teaching/learning and improvement of assessment methods were also discussed.

## RECOMMENDATIONS

It is obvious that Nigeria desires and clamours for technological advancement. It is translated into reality only if there are conscious efforts to prepare the science students adequately using new teaching strategies in the secondary schools here in Nigeria in this 21st century. Therefore, premised on the information garnered from field investigations, documented literature as well as the researcher personal experiences as a science educator, the traditional mode of teaching can not be totally eradicated from this secondary schools in Nigeria but new effective teaching strategies can be used to ensure quality and enhanced performance in this science classrooms. Researcher therefore, deem it fit to recommend these new teaching strategies: student-centred learning; problem based learning, conceptual change teaching, case studies and cooperative learning in the science classrooms in Nigeria. Adequate laboratory and infrastructural facilities should be made available in schools for effective science teaching and learning to take root and thrive where every science student in the Nigerian schools can be actively engaged in their science classrooms. The improvement of assessment using the new teaching strategy in science classrooms should also be made applicable in all schools.

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