

## Inquiry Instructional Method and the School Science Curriculum

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**Abstract:** The crusade to universalize basic education and improve its quality is now very much on the agenda of many countries including the developing ones. Meaning that, there is an implication, there is an overwhelming concern over the quality and relevance of education globally. Undoubtedly, the quality of education is a direct consequence and outcome of the quality of teachers and teacher education. The socialization of the child is a long process which requires careful and systematic application of workable principles as to achieve the desired results. To perhaps improve the student's academic achievement in biology, a shift will be necessary from what has traditionally been experienced in the Nigeria classrooms toward more inquiry teaching practices, which facilitated teaching for meaningful learning. Suffice it to note the importance of inquiry in the science process, as, allowing students to describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. This is the contention in this study. The thesis of this study is to contribute to the ongoing debate on enhancing teaching and learning strategies through innovation and changes in the contemporary epoch of new world order, thus globalization and technology.

**Key words:** Curriculum, inquiry, methods, teaching, school science

### INTRODUCTION

Nwagbo (2001), quoting research reports, noted that teachers shy away from the more effective activity oriented teaching methods in preference for methods that are easy and most times inadequate and inappropriate. But because the quality of any educational programme is the function of those who teach it according to (Akpan, 1987). Teachers are expected to be intellectually and professionally competent as well as dynamic enough to adapt to the dynamics of scientific growth and development and discharge their duties to a much more satisfying level. To buttress this point, it was emphasized that even a good curriculum in a well-stocked laboratory would still not give the desired result in the hands of an incompetent teacher (Ossai, 2004).

Biology as a subject, had witnessed a high level enrolment than any other science subjects in the final year external examination (James and Awodi, 1997). Conversely, there has not been a corresponding increase in students' performances in the examinations, even in schools where necessary facilities for the teaching and

learning are available (Ossai, 2004). If one considers output of education (students/ learning and academic achievement) especially in biology, the school seen to have not been performing so well as revealed by the analysis of the following May/June Senior Secondary Certificate examination result between 1977-1997 in which 1982 and 1983 recorded 82.74 and 79.19% failure rates respectively.

Therefore, quality improvement of our teacher education programme is one of the indispensable needs (Patrick, 2000). Though the place of teaching of biology is at the top of hierarchy of other science subjects, researches in this area have been relatively scanty. The teaching of biology generally conforms to the conventional methods and continues to be dominated by teacher making it as dull and uninspiring as ever before (Kalia, 2005). Various workers such as Aramide (1985), Ogunsola-Bandele and Lawan (1996), Ango and Sila (1986), Ajayi (1998) and Ajaja and Kpagban (2000) have reported the low percentage passes in biology at senior Secondary School Certificate Examination (SSCE) were partly due to ineffective methods of teaching.

## THE CONCEPT OF TEACHING SCIENCE

To teach any subject effectively, one must know what the subject is all about and for what purpose the subject has been introduced into the school curriculum (Obomanu, 1999). Hence, it is pertinent for science teachers to raise questions, thus:

For what purpose was science first introduced into elementary and secondary school programme? What are the historical backgrounds of the development of science programme from their early appearances as part of the general education of children? What are the trends of continuity that has occurred in Nigerian schools science programme? And finally, how has educational / psychological theories influenced the selection, organization and presentation of science materials as part of the school programme?

The questions are important for those engaged in the teaching of science whether at the elementary or secondary school level. It is no gain-saying that interest in science learning is increasing in all countries of the world. Each country is striving towards producing more and better trained corps scientist and technologists. This is justified for; science has lately assured the importance of the foundation of national power and productivity. Therefore, the primary task of the science teacher is the transmission of selected experiences in science to his students.

The Encyclopedia International (1979), define teaching as "the art of informing or instructing or providing guidance, suggesting activities and supplying materials to stimulate learning. The actual process of teaching therefore is the transmission or communication of what is to be learned by the "teacher" to the "learner" in a manner that will enable the learner to develop the necessary skills for the understanding and utilization of what is to be learned.

Teaching may be, regarded according to Gbamanja (1992), as the organization of curricular and relevant resources, and the directions of experiences and activities to facilitate meaningful learning and this leads us to the question, "What is science?"

The science manpower project 1960, defined science as a cumulative and endless series of empirical observations which result in the formulation of concepts, laws and theories with both concepts and theories being subject to modification in the light of further empirical observation (Abdulahi, 1976). Based on this definition science is both body of knowledge and the process of acquiring and refining the knowledge. As a method for tackling problems, the scientific method consists of the

processes of observation, and experimentation leading to a rational explanation for the nature of things or of processes. Often new ways of doing things are discovered in the effort.

Furthermore, the new educational system generally known as the 6-3-3-4 system of education was in a bid to utilize an educational system which should be related to the aims and goals of Nigerian society. According to National Policy on Education (1977), one of the educational aims is to "inculcate creativity" to the child. Teachers can aid, creativity by stimulating students, by uncovering latent talents and by respecting the originality and individuality of their students through inquiry emphasis. The goal of science teachers should be to lead the student from passivity to activity and from imitation to creativity. This new educational system is aimed at presenting the sciences as system of inquiry rather than simply as bodies of knowledge.

**Inquiry teaching/learning theory:** Indeed, several theories of learning have been proposed by psychologists and educationists. Some of the strategies such as Ausubel's meaningful verbal learning, Gagne's hierarchies of skills, Brunner's discovery learning, and Piaget's theory of intellectual development to name only a few possibilities are all meaningful, and all have been shown to work in some circumstances.

Brunner (1960) argues that one can be massive transfer of concepts, principles and strategies from one learning situation to another within the same discipline as well as between subjects. He is an advocate of discovery method of learning. Discovery involves all forms of obtaining knowledge for oneself by use of one's mental processes. This approach is considered same as the problem solving method (Brown *et al.*, 1982) and uses the discovery capabilities of student. Inquiry on the other hand emanated from discovery. It goes further than discovery in the sense that it involves finding some answers or reasons why a certain problem exist, with a view to unavailing some hide races in nature.

Sund and Trowbridge (1973) defined "Inquiry" as a teaching method aimed at finding out how scientists develop, understand and apply new knowledge of ideas through systematic questioning, hypothesizing and experimenting which involves discovery rather than verification of facts ie "search rather than the product". It is an organized directed search whose activities are directed by tentative solution (hypothesis) which determines facts to be selected in terms of relevance by the solution to the problem. Here, the responsibility for learning is placed clearly on the students. He asks

questions and examines possible solutions (Grambs and Carr, 1979).

Following Suchman (1962), believed that individuals have a natural motivation to inquire, the inquiry training model is built around intellectual confrontations. The student is presented with a puzzling situation and inquiries into it. Anything that is mysterious, unexpected or unknown is grist for a discrepant event. Because the ultimate goal is to have the students experience the creation of new knowledge the confrontation should be based on discoverable ideas. Inquiry training according to Suchman originated in a belief in the development of independent learners, it methods requires active participation in scientific inquiry. Children are curious and eager to grow and inquiry training capitalizes on their natural energetic explorations given them specific directions so that they explore new areas more forcefully. The general goal of inquiry training is to help students develop the intellectual discipline and skills necessary to raise questions and search out answers steaming from their curiosity. Thus, Suchman developed the inquiry training and is interested in helping students inquire independently, but in a disciplined way. He wants students to question why events happen as they do and to acquire and process data logically and he wants them to develop general intellectual strategies that they can use to find out why things are as they were.

Like Brunner (1960) and Suchman (1962) believes that students that can become increasingly conscious of their process of inquiry and that they can be taught scientific procedures directly. Schleker (1976) reported that inquiry training resulted in increased understanding of science productivity in creative thinking and skills for obtaining and analyzing information. He reported that it was more effective than conventional recitation methods of teaching in the acquisition of information, but that it was efficient as recitation or lectures accompanied by laboratory experiences.

Ivany (1969) and Collins (1969) reported that the method works best when the confrontations are strong, arousing genuine puzzlement and when the materials the students use to explore the topics under consideration are especially instructional. Both primary and secondary students can profit from the model (Voss, 1982). In an intriguing study, Elefant (1980) successfully carried out the model with deaf children which suggest that the method can be powerful with students who have severe sensory handicaps.

In inquiry processes, teachers act as catalysts, rather than as dispensers of information. They offer students problems, issues and questions and then provide

encouragement for inquiry into the nature of the problems and guidance for seeking solutions. They help students find or pose problems, investigate, and clarify positions and concisions. To function students term and test hypothesis they develop, ultimately arriving at statements of conclusion, generalizations or solutions Grambs and Carr (1979) and Brown *et al.* (1982).

**Inquiry training model:** Much of the current interest in inquiry can be traced back to the work of John Dewey. He maintained that the learner should develop the intellectual tract and sensitivity to solve problems by inquiry constantly to the classroom. The system is based on the scientific method of investigation on which requires posing a problem, generating hypothesis about the problem, testing the hypothesis and applying the solution. (Grambs and Carr, 1979; Brown *et al.*, 1982; Davis, 1976).

The model promotes strategies of inquiry and the value and attitude that are essential to an inquiring mind including Process skills (observing, collecting and organizing data, identifying and controlling variables formulating and testing hypothesis and explanations, inferring), Active, autonomous learning ,Verbal expressiveness, Tolerance of ambiguity, Persistence, Logical thinking (Fig. 1).

Inquiry method develops all the domains of educational behavioural objectives. Joyce and Weil (1978), the essence of the model is the involvement of the students in a genuine problem of inquiry by confronting them with an area of investigation, helping them identify a conceptual or methodological problem within that area of investigation, and inviting them to design ways of overcoming that problem. Thus, they see knowledge in the making and are initiated into the community of scholars. At the same time, they gain a healthy respect for knowledge and will probably learn both the limitations of current knowledge and its dependability.

According to Lippitt *et al.* (1969), a number of models for teaching the disciplines as processes of inquiry exist, all built around the concepts and methods of the particular disciplines. In biological science, it is designed to teach the processes of research biology to affect the ways that students process information, and to nurture a commitment to scientific inquiry. It probably also nurtures open mindedness and an ability to suspend judgment and balance alternatives. Through its emphasis on the community of scholars, it also nurtures a spirit of cooperation and an ability to work with others in scientific inquiry (Fig. 2).

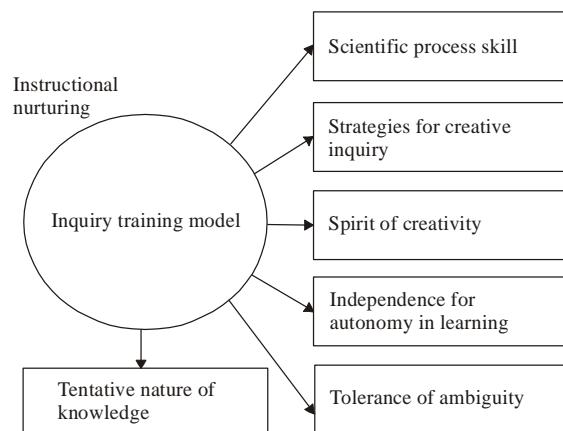


Fig. 1: Instructional and nurturing effects on inquiry training model

#### Inquiry Training Model (Summary chart)

- PHASE ONE
  - Confrontation with the problem
  - Explain inquiry procedures
  - Present discrepant event
- PHASE TWO
  - Data gathering-verification
  - Verify the nature of objects and conditions
  - Verify the occurrence of the problem situation
- PHASE THREE
  - Data gathering – Experimentation
  - Isolate relevant variables
  - Hypothesis (and test) causal relationships
- PHASE FOUR
  - Organizing, formulating and explanation
  - Formulate rules or explanations
- PHASE FIVE
  - Analysis of the inquiry process
  - Analysis inquiry strategy and develop more effective ones.

**Implementing inquiry model:** The global trend in science education is towards science as a basic for all students and in recent years a major movement for the reform of science teaching had developed in many countries. In America, the physical science study committee has been engaged in fundamental reappraisal of science teaching since the 1950's. In England, the Nuffield science teaching project has been work is proceeding in other countries.

In essence, the aim of the new approach is to present the sciences as systems of inquiry rather than simply as bodies of knowledge. To this end, the Biological Science Curriculum Study (BSCS) (Schwab, 1965) precluded curricular and instructional patterns for use in secondary

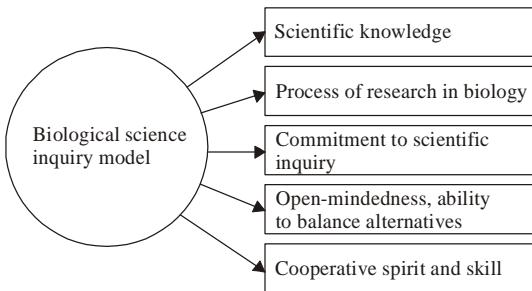


Fig. 2: Instructional and nurturing effects in biological science inquiry model

#### Biological Science Inquiry Model (Summary Chart)

- PHASE ONE
  - Area of investigation is posed to student
- PHASE TWO
  - Students structure the problem
- PHASE THREE
  - Students identify the problem in the investigation
- PHASE FOUR
  - Students speculate on ways to clear up the difficulty.

school biology. The essence of the BSCS Approach is to teach students to process information using techniques similar to those of research biologists—that is, by identifying problems and using a particular method to solve them. BSCS emphasizes content and process. To help students understand the nature of science the strategies developed by the BSCS committees introduce students to the methods of biology at the same time that they introduce them to the ideas and facts (Schwab, 1965). The committee put it rather pungently.

If we examine a conventional secondary school text, we find that it consists mainly or wholly of a series of unqualified, positive statements. “There are so many kinds of mammals”. Organ A is composed of three tissues” Respiration takes place in the following steps”. “The genes are the units of heredity”. The function of A is X”.

This kind of exposition (the statement of conclusions) has long been the standard rhetoric of textbooks even at the higher level. It has many advantages, not the least of which are simplicity and economy of space. Nevertheless, there are serious objections to it. Both by omission and commission, it gives a false and misleading picture of the nature of science (Schwab, 1965). By commission, a rhetoric of conclusions has two unfortunate effects on the students.

It gives the impression that science consists of unalterable, fixed truths. Yet, this is not the case. The accelerated pace of knowledge in recent years has made

it abundantly clear that scientific knowledge is reversionary. It is a temporary codex, continuously restructured as new data are related to old.

Okoro (2002), in support of this identified a case whereby a teacher in a class taught his students that “pure” water refers to the absence of every other substance. When the students were taken to a town water supply purification plant, the public relation officer told them that certain substances were added to the water in order to make it pure. This created confusion among the students, as they could not understand how one could make water pure by adding other substances.

Rhetoric of conclusions also tends to convey the impression that science is complete. Here, the fact that scientific investigation still goes on, and at an ever accelerated pace, is left unaccounted to the student. The sin of omission by rhetoric of conclusions can be stated thus. It fails to show that scientific knowledge is more than a simple report of things observed, that it is a body of knowledge forged slowly and tentatively from raw materials. It does not show that these raw materials, data, spring from planned observations and experiments. It does not show that the plans for experiments and observation arise from problems posed, and that these problems, in turns, arise from concepts which summarize our earlier knowledge.

In a conventional classroom situation the teacher by omission and commission, gives a false and misleading picture of the nature of science. The teacher factor has been identified as critical for the successful implementation of science education. According to (Okebukola, 1995), this factor is obviously major in explaining the deficiencies in the delivery of good quality science education generally. The problem is the teacher who does not understand or who has no interest in the nature of science itself. Many teachers behave and think scientifically base on their training but thy lack an understanding of the basic nature and aims of Science. Secondly, according to (Okebukola, 1995) is the problem of “teach as you were taught” and with this didactic “copy and teach” and “chalk and talk” teaching methods and unfavorable teaching environment, the science taught in the conventional classroom is a mere “web of thought too weak to furniture support but complicated enough to cause confusion”.

Above all, of great importance, is the fact that rhetoric of conclusions fails to show that scientists, like other men, are capable of error, and that much of inquiry has been concerned with correction of error. Rhetoric of conclusions fails to show that our summarizing concepts are tested by the fruitfulness of the questions that they suggest, and though this testing are continually revised

and replaced. The essence, then, of teaching of science as inquiry, would be to show some of the conclusions of science in the framework of the way they arise and are tested. This would mean to tell the student about the ideas posed, and the experiments performed, to indicate the data thus found, and to follow the interpretation by which these data were converted into scientific knowledge (Schwab, 1965).

However, there are several techniques to teach science as inquiry. This is dependent on these three types of inquiry.

- **Guided inquiry:** This is a form of inquiry whereby the teacher structures the lesson. He poses the problem and breaks it down into simpler questions and may even advise about steps which the students should take to answer the questions.
- **Free inquiry:** A form of inquiry which students formulate the problem to be solved, devise methods and technique, to solve the problem as well as carrying out the investigation for a conclusion.
- **Modified inquiry:** This is in between the guided inquiry and free inquiry. The teacher provides the problem and asks the students to carry out the investigation which might be in groups. The teacher acts as a resource person giving assistance to avoid frustration or lack of progress by the students (Brown *et al.*, 1982).

In addition, Inquiry method of teaching could be used in classroom as Discovery/inquiry. An organized direct search whose activities are directed by tentative solutions (hypothesis) which determine facts to be selected in terms of relevance to the solution of the problem. Here we have as follows:

- **Inquiry through questioning:** An inquiry method where the teacher gives the student same appropriate questions which will assist them in organizing their taught and gaining insight.
- **Inquiry through demonstration:** An inquiry method where concepts are demonstrated as fixed facts from where students are required to draw inferences either through questions drawn by the teacher or from their own direct observation (Trowbridge and Sound, 1973).
- **Inquiry through discussion:** A form of inquiry whereby the teacher teaches the students through discussion. The teacher secures feedback as opposed to inquiry through questioning.

- **Inquiry through laboratory work:** According to Schein and Bennis (1965), it is an educational strategy which is based primarily on the experiences generated in the various social encounters by the learners themselves and which aims to influence attitudes and develop competencies towards learning about human interaction.

Indeed, there is the use of what are called “invitations to Enquiry”. Like the functioning of the laboratory, the invitations to enquiry involve the student in activities that enable him or her to follow and participate in the reasoning related to a front line item of investigation or to a methodological problem in biology. This strategy was designed, to show students how knowledge arise from the interpretation of data; to show students that the interpretation of data-indeed, even the search data-proceeds on the basis of concepts and assumptions that change as our knowledge grows; to show students that as these principle and concepts change, knowledge changes too; to show students that though knowledge changes, it changes for a good reason-because we know better and more than we knew before. The basis of this point also needs stress: the possibility that present knowledge may be revised in the future does not mean that present knowledge is false. Present knowledge is science based on the best-tested facts and concepts we presently possess. It is the most reliable rational knowledge of which man is capable (Schwab, 1965).

**Inquiry competence motivation and assessment:** Inquiry training is designed to bring students directly into the scientific process through exercises that compress the scientific process into small periods of time. “What are the effects”? Schlenker (1976) reported that inquiry training resulted in increased understanding of science, productivity in creative thinking, and skills for obtaining and analyzing information. He reported that it was not more effective than conventional method of teaching in the acquisition of information, but that it was as efficient as recitation or lectures accompanied by laboratory experiences. Ivany (1969) and Collins (1969) reported that the method works best when the confrontations are strong, arousing genuine puzzlement, and when the mate. Voss (1983) found that this model is equally helpful to both elementary and secondary students. In an intriguing study, Elefant (1980) successfully carried out the model with deaf children, which suggests that the method can be powerful with students who have severe sensory handicaps. Myer (1985) and Strike (1975) have also found this model to be superior to traditional teaching.

However, in psychology, motivation refers to “the under derive which prompts people to it in certain way. It involves a number of psychological factors which start and maintain activity towards the achievement of personal goals” (Musaazi, 1982). When learners are physiologically satisfied where they feel secured and wanted and where they have the ability to grow in confidence, independence and self esteem through achievement they will seek the intellectual satisfaction provided in school. Motivation affects the amount of time and energy that the learners are willing to devote to learning. Students differ in their need to achieve some are highly motivated by fear of failure while others are not. This is the theory of motivation based on the desirer – sheer will and effort of the learner to develop competence and to solve problems.

Thus, learning by inquiry does not allow students to learn for learning sake or just to acquire certificates. It was reasoned that students could appreciate inquiry only by becoming actively involved in it.

- Develop an attitude conducive to understanding the nature of science and the role of science in environment.
- Understand that there is still much to be learned in science.
- Recognize the importance and limitations of the techniques used in science.
- Appreciate that “science is a body of knowledge forged slowly and tentatively from raw materials”
- Recognize the validity of conclusions of science, the manner in which they arise and are tested.
- Understand that the human mind is the most vital part of the scientific enterprise.

Schwab (1965) distinguishes between two types of inquiries, stable inquiry and fluid inquiry. For Schwab, stable inquiry is short term in the sense that separate problems can be pursued separately and settled in a relatively short time, as for example, during a single or double school period used for an investigation. In a science lesson, stable inquiry will involve:

- The formulation of a problem
- The search for data that will suggest possible solutions to this problem.
- Reformation of the problem to include the possible solutions.
- A determination of the data necessary to solve the problem
- A plan of experiment that will elicit the data desired.
- Execution of the experiment and accumulation of the desired data.

- Interpretation of the data by means of the guiding substantive structures together with previous knowledge possessed by the investigator.

Students thinking must be made visible through assessment. Assessment provides feedback and what is assessed must be in confirmation with ones learning goals. There are two major uses of assessment- formative assessment which provide feedback into an ongoing instructional situation, and summative assessment provide a final judgment between the two kinds of assessment for instance, formative assessment provides data about how students are changing. While summative assessment is concerned with how students have changed.

Using formative assessment to improve learning means - reinforcing the learning of higher achievers, pinpoint the specific learning errors of low achievers, and serve as basis for the corrective prescriptions given to each student. Formative testing provides diagnostic feedback. The recognition of the students' process of reasoning permits the teacher to apply effective reinforcement when necessary.

Stable inquiry thus provides an easy check on the students reasoning as they progress through the investigation. The nature of stable inquiry, particularly with reference to time limitations, allows the teacher to keep in contact with a greater number of students as their progress is usually much closer in time than in fluid inquiry. Fluid inquiry on the other hand, is long – term and continuous. Fluid inquiry illustrates the dynamic nature of science in which knowledge becomes remnant or is refined as the principles of science are changed. The flexibility of fluid inquiry appears limitless and is in accord with the modern definitions of science in which the accumulated structured body of knowledge is subjected to refinement and verification by constant investigation and experimentation using the methods of science (Schwab, 1965).

**Inquiry in science classroom:** Life in classrooms takes the form of a series of "inquiries". Each inquiry starts with a stimulus situation to which students can react and discover basic conflicts among their attitudes, ideas, and modes of perception. On the basis of this information, they identify the problem to be investigated, analyze the roles required to solve it, organize themselves to take these roles, act, report and evaluate these results. These steps are illuminated by reading, by personal investigation and by consultation with experts (Thelen, 1960).

In biology class, the observable interactions which influence students' interest attitudes and participation include student-student interaction, students-teacher interaction and student-materials interaction. Student-

student interaction can be competitive, cooperative or individualistic in nature. Of these three, student-student interaction patterns, research has shown that cooperative interaction has generally the greater positive effect on student interest, attitudes and achievement in science (Okebukola, 1984; Johnson and Johnson, 1975; Johnson, 1976).

According to Okebukola (1984), in the cooperative condition students learn together and have opportunity to engage in interaction relevant to the accomplishment of the learning task. They make decisions by consensus and seek help and assistance primarily from each other. Thus, students' goal achievement is positively correlated; when one student achieves his or her goal, all students with whom he or she is cooperatively linked achieve their goals. Cooperative learning environment is very acceptable and favourable to girls who are thus encouraged to get involved and achieve better in science (Burns and Bird, 1987). While competitive classroom learning environment is not favourable to the interest and achievement of girls, particularly the academically less able ones among them. The more girls are engaged in competitive inquiry activity, the less they learned (Peterson and Fennema, 1985). Whereas, working in small cooperative groups of boys and girls greatly improves the achievement and gains of the students, particularly girls and less able students. Based on this, it is clear that girls perform well in cooperative inquiry class. It is thus instructive that science teachers should organize the classes in small cooperative inquiry groups or peers.

Researches related to school organization patterns indicate that students of both sexes in single-sex schools perform better, have better attitudes to and participate more in science than students in co-educational schools (Akpan, 1987; Lee and Bryk, 1986). According to Lee and Bryk (1986), single -sex schools deliver specific advantages to their students, especially female students in matters concerning academic achievement, education aspiration, sex role stereotyping or attitudes and behaviours related to academics. This will enable the girls develop better attitudes to science and thus improve their achievement in biology.

In view of the advantages of single-sex schools, and since co-educational schools which have their own advantages, have come to stay, researches have been carried out into the effects of gender grouping in co-educational schools. Blasi and Kruse (1991) has empirically shown that grouping students by sex in co-educational schools improves the interest, participation, confidence and achievement of students particularly females in biology. Science teachers in co-educational schools should therefore be advised that separate

arrangement will no doubt improve the achievement and participation of girls in biology inquiry class since it effectively reduces sex-role stereotyping prevailing in co-educational school

In view of the above, to improve interest and participation of girls in science there is need to adopt science books that represent male and female characters on equal bases. According to Mottier (2000) most authors of science textbooks use masculine form of pronouns as sex neutral. Also illustrative diagrams and pictures in science books use male characters more than females as well as male role models than females which females consider science to be preserved of males. The textbooks should not be gender biased in terms to their use of pronouns, illustrative pictures and diagrams, role models etc. sex equity is necessary in our books.

In addition, proper provisions of facilities are necessary for effective inquiry strategies. Inquiry through laboratory work is very necessary because science is best taught in well equipped science laboratories, and students learn science with much ease if taught through activities in the laboratory (Njoku, 1990). Using inquiry through laboratory work, they develop more positive attitudes to science all schools offering biology should have well equipped biology laboratory and the ancillary personnel needed to facilitate the work of the biology teacher.

It has been said that the apprentice or learner can only be as good as his/her master or teacher. Inadequate science teacher education and lack of teaching and learning resources in the schools are at alarming rates consequently many biology teachers are in schools that have no formal laboratory and in cannot effectively adopt inquiry in science classroom teaching. In many cases the available laboratories are not equipped or are inadequately equipped (Ayodele, 2002) teaching resources are not just scarce, but no budget is planned to provide some of them. According to Njoku (2004), this is particularly true in rural areas where there are no science laboratories and public libraries and the schools often do not have their own libraries/laboratories to serve the teachers and the learners; and where such libraries exist, they do not stock journals.

Although changing the status quo is not easy, starting the process of change is the only way the objectives, of the inquiry method of teaching can ever be attained, however the enormity of the task.

**Advantages and disadvantages of inquiry method of teaching/learning:** According to Brunner (1961), the knowledge discovered by the individual himself is the most uniquely personal thing about that individual. He maintained that “the idea of inquiry is for students to put things together for themselves to be their own discoveries.

Some advantages of inquiry method are summarized as follows:

- It makes the students opportunity to think
- It gives the students opportunity to think carefully about ideas, problems and questions being considered valid by class.
- It creates room for students' full participation which increases their curiosity both inside and outside classroom work.
- It makes the students to develop the spirit of personal initiative.
- It encourages patience, co-operation, unity and decision making amongst the students.
- It arms the students with the right type of attitudes, values. Skills and knowledge that enable them explore their social environment.
- It increases students understanding of processes, concept and relationship.

**Disadvantages:**

- It is time consuming. That is, it may involve several stays or weeks before completion.
- It puts the students on a lot of task. The students will be busy working towards completion of the task given to them at the neglect of their other tasks. They work hard to meet up the stipulated time tagged for handing in of their papers.
- It may be too expensive when it involve trip making to places where the facts are available
- As much is expected of students, they could be frustrated particularly if they cannot find appropriate dues to solve problems or if they cannot solve them at all.
- If often leads to withdrawal from lessons or schools especially when the task is difficult to solve.
- It is not always possible to use inquiry in all topics or situations especially in large class series or where a large amount of materials is required to be taught in a limited time.

Having stated the advantages and disadvantages of inquiry methods, Ango and Sila (1986) in her article gave serious justifications for using inquiry method instruction become student centred; expectancy level increases; develop talents; avoids learning only at the verbal level and mental accumulation and assimilation of facts are encouraged.

According to Okoro (2002), in many countries particularly in the developing countries, the science education in general education in schools does not seem

to help students achieve scientific and technological literacy or feel confident either in applying their knowledge or dealing with societal problems. Therefore, to achieve meaningful learning, appropriate strategies, methodologies or techniques of teaching become very necessary.

In 1996, the National Research Council (NRC) published the National Science Education Standards (NSES) with the intention of presenting “a vision of a scientifically literate populace”. The NRC created the standards around a central theme “Science Standards for all students. This theme emphasizes the importance of inquiry in the science process, allowing students to describe objects and events, ask questions, construct explanation test those explanations against current scientific knowledge, and communicate their ideas to others. In teaching science with an inquiry emphasis, the assumptions of the diverse populace are considered, and critical and logical thinking skills are fostered.

If standards are going to become a reality in the classrooms in Nigeria, a shift will be necessary from what has traditionally been experienced in the nation’s science education classrooms. Brooks and Brooks (1993) describe what students typically experience in traditional classrooms as follow:

- Curriculum is presented part to whole, with emphasis on basic skills.
- Strict adherence to fixed curriculum is highly valued.
- Curricular activities rely heavily on text-books and workbooks
- Students are viewed as “blank slates onto which information is etched by the teacher.”
- Teachers generally behave in a didactic manner, in disseminating information to students
- Teachers seek the correct answer to validate students’ learning.
- Assessment of students learning is viewed as separate from teaching and occurs almost entirely through testing.
- Students primarily work alone.

The NSES emphasizes teaching for meaning and understanding. McTighe *et al.* (2004) identified five key principles necessary for teaching for meaning and understanding:

- Understanding big ideas in context is central to the work of students.
- Students can only find and make meaning when they are asked to inquire, think at high levels, and solve problems.

- Students should be expected to apply knowledge and skills in meaningful tasks within authentic contexts.
- Teachers should regularly use thought provoking, engaging, and interactive instructional strategies.
- Students need opportunities to revise their assignments using clear examples of successful work, known criteria, and timely feedback.

All of these principles are found in the National Science education standards and represent a shift the traditional classroom experiences. In addition to the five key principles identified for teaching for meaning and understanding, science teachers themselves identified goals that are congruent with the outcomes targeted in the standards (Pennick and Bonnstetter, 1993). The goals for students were:

- Having a positive attitude towards science
- Using knowledge learned to identify and solve problems
- Developing creativity
- Communicating science effectively
- Feeling that the acquired knowledge is useful and applicable
- Taking actions based on evidences and knowledge
- Knowing how to learn science.

A focus on teaching for meaning and understanding, and achieving these seven goals requires changes in teacher practices.

Again, Brown *et al.* (1982), while maintaining that the inquiry method has many advantages such as generating interest and enthusiasm in the students in enhancing entail thinking and skills of scientific investigation, have also observed that it is time consuming and may not be possible in all situations.

## SUMMARY AND CONCLUSION

What we have done in this paper is centered on “inquiry” as “science standards for all students” with the intention of presenting “a vision of a scientifically literate populace”. It identifies the characteristics of inquiry techniques for quality teaching/learning, explores the inquiry training model phases, stated the current inquiry in a science classroom and advantages and disadvantages of inquiry method of teaching/learning. Since no method of teaching/learning is problem free (Davis, 1976).

Based on the review, when using the inquiry method, teachers should no longer use laboratory expenses merely to verify previously stated principles. Ways should be

sought to encourage students to discover ideas for themselves and to learn the sciences by developing, so far as possible the view points and modes of attack of scientist in confronting problems.

It would seem more economical of time and more conducive to the teachers to guide the experience of the students so that they are neither overwhelmed by the complexity of the stimulus situation nor do they miss the essential experiences for ensuring the adequacy of the concepts. The teacher who guides the science experiences of the students is making the best approach with an inquiry emphasis.

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