Inquiry Method as a Strategy for Teaching Integrated Science (Basic Science) in Junior Secondary Schools in Zamfara State Nigeria

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Integrated science is a foundational science subject at junior secondary school level of education that introduces learners to science and science-related subject at senior secondary schools and tertiary institutions. For good foundation to be laid, It needs to be taught with an approach which will develop in the learners' reflective thinking and scientific investigation skills. This paper therefore focuses on the inquiry method as teaching strategy for teaching and learning of integrated science in junior secondary schools. Some suggestions to overcome the challenges were made as teachers should first follow the programme that would make students acquire science process skills, teaching science process skills should never be neglected giving excuses such as shortage of time and overloaded syllabus etc

Introduction

There is a relative stability generally in defining science as a product of knowledge as well as a process of generating knowledge (National Teachers; Institute [NTI] 2007) cited in Abubakar, Abubakar, Ardo, Suleiman and Itodo (2008).Mohammad, Ahmad, Liman and Bello (2008) defined Integrated science as a course of study which is devised and presented in such a way that students gain the concept of fundamental unity of science, the commonality of approach to problems of scientific nature and are helped to understand the roles and functions of science in everyday life and the world in which they live.

Bajah (1983) in Shehu, Muhammad and Twambuwal (2010) defined Integrated science as approaches in which the concept and principles of science are presented so as to express the fundamental unity of scientific thought and to avoid premature or undue stress on the distinction between the various scientific fields. Onaolapo (2009) described integrated science as a fundamental science subjects at senior secondary schools and tertiary institutions. She further said however, a foundation that is not solidly laid cannot sustain the "structure" or build of future science and science-related subjects.

Integrated science involves a process approach. Remziye, Jeter, Sevgul, Zehra and Mera (2011) defined science process skills as transferrable skills that are applicable to may sciences and that reflect the behaviors of scientist. They further said the skills facilitate learning in physical sciences, ensure active student participation, develop the senses of undertaking responsibilities in their own learning, increase the permanence of learning and also help students to acquire the ability to carry out research.

Ostlund (1992) in Remziye et' al (2011) further said the process approach of an important method in teaching science lessons and process skills are the building blocks for critical thinking and inquiry in science.Science process skills are based on scientific inquiry, and teaching science by inquiry involves teaching students science process skills, critical thinking, scientific reasoning skills used by scientist.

(Hackett,1998 in Remziye et' al 2011).

Concept of Inquiry Method

According to Olure (2010), inquiry methods are processes involved in resolving problems. These strategies are activity-oriented, thought –provoking creative methods in which students out of curiosity probe, investigate, interpret issues and problems with a view of providing solutions through reflective thinking and rational decision and relation to method of inquiry.

Olson and Louk (2000) said inquiry science teaching is teaching science by having students engaged in more science activities and exercises and encourage learners on how scientists work. Also, students are engaged in simple processes such as observing, comparing, contrasting and hypothesizing (Cuevas, Lee, Hart and Deaktor [2005]). Scientific inquiry exercise typically serves as the primary source of science process skill development, and inquiry is used to teach science process skills. (Wilke & Strait [2005]). Inquiry method involves activity and skill but the focus is on the active search for knowledge or understanding to satisfy a curiosity.

Description of Inquiry Method of Teaching

Inquiry entails practicing of attitudinal skills such as honesty, open mindedness and perseverance when carrying out science and technology tasks. Inquiry means more than simply answering questions or getting right answers and emphasizing it. It is an innovative teaching method which encourages active participation of students in the learning process (O'Bannon, 2002 and Exline,2004). Inquiry is an approach to learning whereby students find and use a variety of sources of information and idea to increas their understanding of a problem, topic or issue (Kuhlthau, 2007). Inquiry requires more than simply answering questions or getting right answers, and emphasizes discovery rather than telling (Guisti 2008). The word inquiry according to Campell (2006) loosely means 'an investigation' but its meaning in the realm of science education is much more complex. It includes questioning, designing, conducting and experiment and communicating the result to others or the society which mirrors scientists.

Inquiry also espouses investigation, exploration, search, quest, research pursuit and study (Exline, 2004). Inquiry is a natural introduction to the branch of epistemology known as 'Nature of science' which deals with the characteristics of scientific knowledge (Kirshner, 2006). Thus Guisti (2008) maintains that in science classroom that the term used most often to refer to students – centered approach is inquiry. Inquiry engages interest and challenges students to connect their world with the curriculum (Kuhlthau et al, 2007). David (1993) views inquiry as a set of behaviours involved in the struggle of human beings for reasonable explanation of phenomena about which they are curious, involving activity and skill, with focus on the active search for knowledge or understanding to satisfy a curiosity'. The objective of inquiry teaching is often a process (Orlich, 2001) and as a process it requires a high degree of interaction among the learners, the teachers, the materials, the content and the environment.

Inquiry based teaching has been of great influence in science education, since the publication of the U.S National Science Educational Standards aimed at turning the traditional 'cook book' approach to science education into hands-on involvement and

development of reasoning abilities in learners (Clark, 2006). The philosophy of inquiry based instructions finds it antecedents in the work of Piaget, Dewey, Vygotsky, 2006), with the view that the learner is a 'constructor' of knowledge and not an empty container to be filled and as such should not be taught bald facts but should be made to understand and explain what he is learning (Campbell, 2006; Guisti, 2008). Inquiry process starts from birth and continues till death (Exline, 2004). It begins with gathering information and data through the application and use of human senses: seeing, hearing, touching, tasting and smelling (Saakatchewan, 2010). Effective inquiry is more than asking questions but involves a complex process of converting information and data into useful knowledge (Martin-Hansen, 2007). Thus the essence of inquiry process is to ask questions that stimulate students to think critically and formulate their own questions and construct their own knowledge. Inquiry emphasizes on how we come to know and less on what we know (Guisti, 2008). It involves active participation of students in the learning process, it allows for high degree of interaction among the learners, the materials the content and the environment and also enables both students and teachers to become persistent askers, seekers, interrogators, questioners, ponders, and problem solvers (Orlich , 2006).

Inquiry teaching emphasizes the development of inquiry skills and nurturing of inquiry habits of mind that will enable individuals to continue the quest for knowledge throughout life.

Hanson, (2005) maintained that learning becomes more effective and long lasting when learners plan their own question, analyze and discuss their findings and finally construct their understanding. Inquiry based instruction is not only concerned with the preparation for long life learning but also extends knowledge beyond the classroom doors (Campell, 2006). Inquiry is focused on using and learning content as a means to develop information processing and problem solving skills and enables students to experience classroom events like real scientists. Inquiry is an integral part of the learning experience and can be used in both traditional class room problems and laboratory experience.

The essence of inquiry is to ask questions that stimulate students to think critically, construct knowledge using scientific processes such as observing, classifying, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing and experimenting which help students to build knowledge and communicate what they have learned (Standard Course of study, 2004). As students question, investigate and solve problems; they also learn to transfer these skills to other areas of life (Campell, 2006). Inquiry-based teaching has many benefits to knowledge acquisition as observed by (Okwor, 2007; Guisti, 2008). These include: inquiry encourages active participation of learner in the learning process and help learners to build self- concept and knowledge; it facilitates retention and transfer of knowledge to new but similar situation; it arouses the interest of learners and promotes intrinsic motivation rather than extrinsic motivation; it contributes to the development of effective thinking, creative expression, critical analysis and local reasoning. Inquiry orientation prepares students for learning by providing motivations for the activity, creates interest, generates curiosity and makes connections to prior knowledge, thereby identifying learning objectives and criteria for success (Hanson, 2005). Inquiry is important in the

generation and transmission of knowledge; hence there is no authentic investigation or meaningful learning if there is no inquiry mind, seeking an answer, solution, explanation or decision (David, 2003). Inquiry helps students to think creatively and critically and can be applied to all disciplines (Kulhthaul, 2007).

Theoretical Framework on Inquiry Method

Inquiry based teaching and learning finds its antecedents to the works and philosophies of Dewey, Lev. S Vygotsky, Jerome Brunner and Jean Piaget, among others (Kirshner , 2006). The aforementioned philosophers and cognitive psychologists based their learning theories on constructivism. The cognitive paradigm of constructivism shifts the focus of responsibility for learning from the teacher to the learner. Constructivism sheds light on the learner as an important agent in the learning process rather than in resting the power on the teacher (Thanasoulas, 2009).

An important tenet of the constructivism philosophy is that knowledge is constructed by different thought processes and partners of thinking. For learners to construct knowledge individually or collectively, each learner has a tool kit of conceptions and skills with which knowledge is constructed to solve problems presented in the environment (Orlich, 1998).

John Dewey's Cognitive Theory

Dewey (1938) was a philosopher, psychologist and educational reformer who contributed and influenced education and social reforms especially in such topic like inquiry teaching and learning among other (Wikipedia, 2011). Dewey states that 'knowledge emerges only from situations in which learners have to draw them out of meaningful learning. Cognitive theories look beyond behavior to explain brain-based learning. Cognitivists consider how human memory works to promote learning. For example, the physiological processes of sorting and encoding information and events into short term memory and long term memory are important to educators working under the cognitive theory. The major difference between gestaltists and behaviorists is the locus of control over the learning activity. The individual learner is more key to gestaltists than the environment, (Thanasoulas, 2009).

Dewey argued that education and learning are social and interactive processes and that the school as a social institution provides an environment in which social reforms can and should take place. He sees the classroom as a social context where students can take part in manipulating materials and thus form a community of learners who construct their knowledge together. Dewey believed in one permanent frame of references; namely the organic connection between education and personal experience. He maintained that every experience enacted modifies further experience and results in positive attitude and growth of understanding. Another vital issue raised by Dewey is that, he believed that students thrive in an environment where they are allowed to experience and interact with the curriculum, as such Dewey emphasized that all students should have the opportunity to take part in their own learning. Exline (2004) maintained that Dewey was of the view that the primary responsibility of educators is to assist shaping the experience by providing environing

condition that will help students to utilize their surroundings to build up experience that interact with personal desires of the students to make learning take place.

Historical Perspective of Inquiry Method

The inclusion of inquiry into science curriculum was recommended by Dewey (1910), a former science teacher. Dewey considered that there was too much emphasis on facts without enough emphasis on science for thinking and an attitude of the mind. Dewey encouraged K– 12 teachers of science to use inquiry as a teaching strategy where the scientific method was rigid and consisted of the six steps: sensing perplexing situations, clarifying the problem, formulating a tentative hypothesis, testing the hypothesis, revising with rigorous tests, and acting on the solution. In Dewey's model, the student is actively involved, and the teacher has a role as facilitator and guide. In 1916, Dewey had encouraged that students be taught so that the students could be adding to their personal knowledge of science. To accomplish that, students must address problems that they want to know and apply it to the observable phenomena. Dewey's model was the basis for the Commission on Secondary School Curriculum (1937) entitled Science in Secondary Education.

Subsequently, Dewey (1944) modified his earlier interpretation of the scientific method to accomplish his goal of reflective thinking: presentation of the problem, formation of a hypothesis, collecting data during the experiment, and formulation of a conclusion. According to Dewey (1938), problems to be studied must be related to students' experiences and within their intellectual capability; therefore, the students are to be active learners in their searching for answers.

Sputnik and Inquiry

The launching of Sputnik I on October 4, 1957, caused the Nation to question the quality of the science teachers and the science curriculum used in schools. Earlier, the National Science Foundation (NSF) had funded the development of an innovative physics curriculum (Physics Science Curriculum Study in 1956; DeBoer, 1991). The subsequent physics curriculum (Physical Science Study Committee, 1960) and other science curricula (biology, chemistry, physics, earth science, and elementary), with funding from NSF, provided for the development of curriculum and professional development for implementing the curriculum, with an emphasis on "thinking like a scientist" (DeBoer, 1991). There was also an emphasis on science processes as individual skills (i.e., observing, classifying, inferring, controlling variables, etc.). Joseph (1966) believed that students should view science as a series of conceptual structures that should be continually revised when new information or evidence is discovered. Earlier, Schwab (1960) had described two types of inquiry: stable (growing body of knowledge) and fluid (invention of new conceptual structures that revolutionize science). Schwab considered that science should be taught in a way that was to be consistent with the way modern science operates. He also encouraged science teachers to use the laboratory to assist students in their study of science concepts. He recommended that science be taught in an inquiry format. Besides using laboratory investigation to study science concepts, students could use and read reports or books about

research and have discussions about problems, data, the role of technology, the interpretation of data, and any conclusions reached by scientists.

Schwab called this “enquiry into enquiry” (Duschl& Hamilton, 1998, p. 1060).

Rutherford (1964) considered inquiry as both content and concepts that are to be understood in the context of how they were discovered so for future inquiries.

Challenges related to inquiry

Below are four challenges that teachers incur when implementing scientific inquiry in classrooms according to Cassie et al (2011).

1. How can we Measure the Quality of Inquiry as Implemented in the Classroom?

   Despite the perception by class room science teachers that inquiry is regularly occurring in the classroom, the quality of this inquiry tends to be confirmatory or activity centered in nature where the teacher explains a phenomenon or concept and then challenges to inquiry teaching. Science teachers direct the student in how to work with the concept via a prescriptive activity. While this approach may be appropriate when mastery of a skill is of primary importance such as learning how to perform a titration or how to use a microscope, it is not appropriate when trying to get students to develop critical thinking skills through investigation.

2. How Can Teachers Use Discourse and Discussion to Encourage More Effective Inquiry-Based Learning?

   In some disciplines like mathematics the quality of discourse in a classroom is a surrogate for level of thinking within the discipline. Science discourse can cause students to become disengaged from science if they are not accustomed to talking about science. But science discourse can be used as a way to encourage inquiry. Science discourse creates its own set of challenges because of the specialized language necessary to understand the discipline. However, this language or set of words is necessary for students to truly inquire about science and with scientists. In general, school science requires students to integrate the practices of prediction, observation, analysis, and presentation with science reading, writing and language use (Lee & Frad, 1998). This ability to ‘talk science’ has served as a gatekeeper to the sciences, preventing many students from having access to academic success and successfully engaging in scientific inquiry (Lemke, 1990).

3. How Can We Get Teachers to Think of Content and Inquiry as not Mutually Exclusive, but Rather Aspects of the Same Goal?

   One often hears teachers complain that they can not implement an inquiry classroom because they have so much content to cover. With the pressure of high-stakes testing and curriculum standards sometimes emphasizing breadth instead of depth, teachers struggle with the amount of content they need to cover. Often times, this struggle leads them to rely on direct instruction to more efficiently convey scientific knowledge to students (Duschl, 1990). Rather than learning scientific principles in an

isolated and superficial manner, science teachers must learn to use strategies to facilitate student understanding of both inquiry and content knowledge.

4. How Can Teachers Learn to Manage an Effective Inquiry Classroom? One of the greatest concerns for teachers in implementing inquiry based instruction is the fear of losing control, control of instruction, control of students, and control of the class. Unless teachers address this fear, they will likely continue to rationalize their unwillingness to implement inquiry instruction instead of asking what is best for students and then working to achieve that goal. After all, management issues are the main reason that people leave the teaching profession (Barmby, 2006). With knowledge and effort, however, this fear can be addressed and overcome.

Remedies to the Challenges of Inquiry Method

1. Teachers can, however, improve the quality of inquiry being facilitated in the classroom if they are provided a mechanism to transform their instructional practice. The support necessary to help teachers transformation usually includes a combination of approaches (e.g., curricular, professional development, learning communities, administrative), but for lasting success, it needs to be clear, focused, and sustained over time (Supovitz& Turner, 2000).
2. Providing Feedback: teachers should examine their questioning techniques: Teacherquestioning techniques are a central component to leading classroom discussions. Close analyses of classroom interactions expose unspoken classroom rules and previously unnoticed norms for classroom behavior. The teacher should encourage the use of student-to-student discussion in scientific discourse this will promotes scientific inquiry as the dialogue and feedback is continuous and not predetermined by the teacher. Teachers can promote inquiry through feedback and continuing the conversation.
3. Providing Follow-Up Information: Another way teachers can promote inquiry in their classrooms is to provide follow-up information to extend students' ideas, highlight the significance of students' contributions, and make connections to other experiences. Then, the teacher can help students devise a research problem, think about a variety of solutions, and reconsider their procedure. Triadic dialogue can serve an important nonevaluative interactional function allowing teachers and students to construct knowledge as well as create a space for teachers to formatively assess students' knowledge. When teachers are not just evaluative but also supportive, it provokes deeper thinking beyond simple recall.
4. Building a Solid Presence:A commanding classroom presence carries a firmness, fairness, confidence, and "withitness" that allow the classroom to operate safely and respectfully, thus allowing and encouraging learning to take place. Though these qualities tend to improve with time and experience, they can also be learned so that

novice teachers can establish a commanding presence and quickly pass the “tests” that their students will inevitably send their way. A teachers’ firmness is often necessary in helping set reasonable boundaries for guiding classroom interactions. Treating students with impartiality and equity means addressing the unique needs of each learner, which requires that all are treated equitably Thus, successful teachers avoid playing favorites and focus on meeting the needs of all learners in the classroom. Confidence in teaching, enhanced through an examination of the strengths and weaknesses in their teaching practice. Possessing a strong understanding of science content knowledge is a great step in building

5. Creating Strong Relationships in a Respectful Environment: The needs, the abilities, and the goals of our students are all unique, so our career is a personal one that requires a professional rapport with and understanding of each student that we encounter. Thus, our task as teachers includes facilitating the development of a caring and respectful learning environment (Marshall, 2008). Even though gaining respect may take more time in some settings than others, there are still things that can be done. Let the students know that you have general expectations regarding decency and civility that all must adhere to. Students don’t have to agree with everyone in the class, but the teacher must set expectations that students should listen to each other, hear each other out, and find appropriate ways to dissent when appropriate.

6. Setting High Expectations: Expectations can be co-created with students. When students feel they have a voice and ownership in their learning, they are more likely to engage in learning and defend it when scoffed at by peers. One means of setting expectations is to have students set short and long-term goals. Long-term goals may be about their performance in the course overall. Short-term goals may have to do with what they will try to achieve today. Having students focus on clear goals each day helps them both to organize and prioritize, which are two very difficult things for many students. Encouraging students to set their own goals and meet those goals on a day-today basis provides an ongoing challenge for students and may minimize boredom.

Recommendations

To overcome the challenges confronting inquiry method in the teaching and learning of integrated science, the following recommendations are made:

- Teachers should first follow the program that would make students acquire the science process skills.
- Teaching science process skills should never be neglected giving excuses such as shortage of time and overloaded syllabuses.
- The teacher should use student-centered approach in the teaching of integrated science in order to make learning meaningful.

- Teacher should see that the use of inquiry method is well coordinated.
- Facilitates and materials which can help the teachers in using this method of inquiry (in case of an inadequately equipped science laboratory) should be provided for the teachers.
- More qualified teachers of integrated science should be provided for junior secondary schools.
- Emphasis on coverage of syllabus only rather than the acquisition of knowledge should be discouraged.
- In-service training and retraining through seminars and workshop where teachers can be trained on how to embark on inquiry methods of teaching should be organized on a regular basis.
- Application of students centered approach of teaching should be made compulsory in the teaching and learning of integrated science in junior secondary schools.
- Teachers should improvise for teaching materials where they are not available,

CONCLUSION

Since student-centered method of teaching are in line with the current trends in educational reforms, if it is used wisely during the teaching and learning of integrated science, will enhance learning and a solid foundation for science and science-related subjects can be laid.All hands must be put on deck to ensure that the recommendations made in this paper are properly addressed and implemented as this will bring a lasting solution to the numerous challenges of teaching basic science in our junior secondary schools.

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