TEACHING METHOD IN SCIENCE EDUCATION: THE NEED FOR A PARADIGM SHIFT TO PEER INSTRUCTION (PI) IN NIGERIAN SCHOOLS

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ABSTRACT

Nigerian schooling system is divided into three levels. Students' academic performance in science at both the secondary and tertiary level of this schooling system has been to many factors. One of these factors is teacher's strategy of teaching. That is why this paper is advocating for a shift in the pedagogy of teaching in science education. Based on the weaknesses of the lecture and other teaching pedagogy in science, the paper considered Peer Instruction (PI) to be a better alternative. Peer Instruction is a research-based pedagogy developed for teaching large introductory science courses. It is a method created to help make lectures more interactive and to get students intellectually engaged with what is going on. Lectures in PI consist of short presentations on key points, each followed by short conceptual questions called ***ConcepTest***, typically posed in a multiple-choice format, on the subject being discussed. The choice of PI is based on several research studies that confirmed its effectiveness. The underpinning theories for this paper are social constructivism and constructive controversy because they viewed learning through interactions and argumentation. The paper suggested some recommendations.

Keywords: teaching pedagogy, authentic learning, rote learning, peer instruction, *ConcepTest*.

INTRODUCTION

Nigerian school system is divided into Primary, Secondary, and Tertiary school. Pupil spends six years in primary before they move to a secondary school where they also spend six years. The six years of secondary schools are divided into three years of Junior Secondary School (JSS) and three years of Senior Secondary School (SSS). The last level of the educational system is tertiary school level. These are the University, Polytechnics and the College of Education. Number of years spent in these institutions depends on the type of course. However, for the science education, irrespective of the kind of the institution, the maximum year allowed is 5years.

Science education is not clearly defined in primary school in Nigeria, except for the study of basic science technology. In the secondary schools, there is basic science at the JSS level. At the senior secondary School (SSS) level, there is biology, chemistry and physics taught separately. At a tertiary level, the main focus of this paper, science education is clearly defined to be biology, chemistry, and physics studied together with the principle and method of education.

Many teachers handling the science subjects in most of our secondary schools specializes in science, not in science education (Omosewo, 2009). Therefore, these teachers lacked appropriate instructional strategies for teaching and often used lecture method. Science education in Nigerian schools is faced with many challenges, one of such challenges is the

out-of-field teaching. This is when a teacher is assigned to teach subjects for which he or she has not got adequate training and qualification (Ingersoll, 2002). These categories of teachers need a change of teaching method as most of them teaches by the lecture- based instruction. This lecture method has been criticized for lack of effective interactive approach and caused poor academic performance in science education.

The performance of students in science subjects in the resent time has not been very good (Erinosho, 2013; Crouch, Watkins, Fagen and Mazur, 2007). The concern for every Nigerian is what the causes of this poor performance are. Among the causes of this poor performance is the teachers' method of teaching (Wanbugu, Changeiywo and Ndritu, 2013); Oladejo, Olosunde, Ojebisi and Isola, 2011). Based on this, it is important to review the different type of teaching methods in science education, their disadvantages and the need for a shift of paradigm.

TEACHING METHODS IN SCIENCE EDUCATION

There are different teaching methods employed in science education in Nigerian tertiary institutions. Miles (2015) asserted that it is expected of a teacher to implement a range of instructional strategies that will bring academic success to all the science students. For any method to be able to bring good result in the present age, it should be a method that promote maximum social interaction. Social interaction between students and between teacher and student plays a crucial role in learning (Nguyen, Williams, and Nguyen, 2012). These authors further stressed the need for the students to be provided with a supportive, open and interactive environment as this could help them discover knowledge. The teaching methods commonly used in science education classes are lecture and demonstration method. These methods shall be briefly discussed.

Lecture method is often used to deliver a large amount of information to the students in a short period (Berry, 2008). According to Gehlen-Bauum and Weinberger (2014), lectures are designed to deliver a new information to a large group of students. This method is known to be effective in dealing with a large class. However, it could also be used for a small class. Research indicates that this method dominates most of the tertiary institutions (Deslauriers, Schelew and Wieman, 2011).

Research shows that students' retention in a lecture-based science courses is weak. According to Bok (2006), an average students only retains 42% of what he or she learned after the end of the lecture and 20% one week later. Research shows that teaching method like the lecture method commonly used does not help the students to acquire sufficient functional understanding (Bernhard et al., 2007). Berry (2008) argued that lecture method lacks the effectiveness of an active learning approach. In the opinion of Fagen and Mazur (2003), lecture method causes the bad reading habit among the students. Franklin, Sayre, and Clark (2014), students taught in lecture-based classes learn less than those taught with activity-based reformed methods. Lecture method is frequently a one – way process unaccompanied by discussion, questioning or immediate practice that makes it a poor teaching method (Hatim, 2001; Al-Rawi, 2013). Lecture method concentrates on information rather than learners (Al-Rawi, 2013). In the lecture method the teacher tell the students what to do instead of activating them to discover for themselves (Miles, 2015).

Demonstration teaching method is a useful method of teaching because it improves students' understanding and retention (McKee, Williamson, and Ruebush, 2007). According to Al-Rawi, 2013), the demonstration is effective in teaching skills of using tools and laboratory experiment in science. However, the time available to perform this demonstration is very limited in a classroom setting. Therefore, a demonstration often designed to allow students to make observations rather than through hands-on laboratory (McKee, Williamson, and Ruebush, 2007).

THEORETICAL MODEL

The importance of educational theory cannot be underestimated as it acts as a road map or building plan guiding teaching and learning. Therefore, the underpinning theories in this paper are that of constructivism and Constructive controversy theory. The constructivism theory emphasizes that learning should be an active process in which learners construct new ideas or concepts based upon their current or past knowledge (Brandon and All, 2010). According to these authors, the constructive theory model sees constructivism as a spiral with the students at the center of the spiral making students the center point of learning. According to Brooks and Brooks (1993), a teacher should encourage student critical thinking and inquiry by asking them thoughtful, open-ended questions, and encourage them to ask questions of each other.

The constructive controversy involves deliberative discussions aimed at creative problem solving (Johnson, Johnson, and Tjosvold, 2006). Students must be skilled collaborators, and follow the norms of cooperation and the rules of rational argumentation. Students are strongly motivated to produce solutions, and display high-level reasoning and greater mastery and retention of new knowledge gained. They generate high quality and creative solutions. The constructive controversy exists when one person's idea, conclusions, and opinions are not compatible with another person's ideas, conclusion, and opinion, but the two seek to reach a consensus on the solution to the problem or the course of action to take in a situation (Johnson and Johnson, 2003). Constructive controversy is not a debate nor is it an individualistic approach to a controversial issue. It is a procedure for cooperative learning where individuals with different, incompatible views agreed on a position based on evidence and reasoning (Johnson and Johnson, 2007).

According to Daniel and Canjander (2010), constructive controversy is on the basis that discussions and controversies may create a good starting point in an attempt to understand a complex problem. Students will improve their skills to constructively and by innovation, think and find solutions to complex problems. When one person's ideas, information, conclusions, theories, or opinions are incompatible with those of another -- and the two seek to reach an agreement (Smith, 2013). This is the ultimate goal of the constructive controversy theory.

The essence of adopting the two theories among many others is because the two are the most relevant to the subject under discussion. PI is a pedagogy that its strength lies in the classroom interactions between the teacher and the students and also between student and student. PI cannot succeed without social interaction Rosenberg, Lorenzo and Mazur (2006) in the classroom, and that is why social constructivism is best for the paper. On the other hand, constructive controversy theory is germane to the paper because there is no single path leading to correct answer in PI. Students must be able to convince one another Mazur (1997)

through a logical argument before reaching a consensus on any answer when PI pedagogy is adopted.

Learning by memorization in science classes is common because students have not been actively involved in the classroom activities (Mazur, 1997). It is not surprising to see in science education a student with a good grade but cannot link his or her classroom experience with the real-world problem Crouch, Watkins, Fagen and Mazur, 2007). The reason is that he or she has not learned through authentic learning instruction. Authentic learning and PI have several common characteristics, and that is why it is important to have a review of it.

AUTHENTIC LEARNING

Authentic learning typically focuses on real-world, complex problems and their solutions, using role-playing exercises, problem-based activities, case studies, and participation in virtual communities of practice (Lombardi and Oblinger, 2007). Students are actively working, participating in discussions, hunting for information, and this make them enjoy the authentic learning (Mims, 2003). Authentic learning activities are designed to give students 'real-world' experiences. Authentic learning should be an inquiry into the nature that enables students to develop knowledge and skill for a successful learning (Barron and Chen, 2008). Authentic learning provides students with the opportunity to learn for themselves in a controlled environment where the teacher can help and guide students who are experiencing difficulty (Schoffstall and Gaddis, 2007). Authentic learning is a learning by doing. It is an active learning where students are not passive. It is an inquiry method of learning. Study shows that authentic learning is important for developing critical thinking skills and developing the scientific contents (Apedoe, Walker and Steeves, 2006).

In other to have a learning where students can favorably apply classroom theory to real - world problems and improve students' academic performance in science education, there is the need for a shift of paradigm of pedagogy. The shift must be to an activity-oriented classroom practice. Miles (2014) supported this that science teachers should incorporate methodologies that require a greater level of students' activity. It should be a research-based instruction that allows maximum student-to-student interaction for learning purpose.

The thrust of this paper, therefore, is changing of teaching paradigm to PI because it is an interactive pedagogy. It engages students during class through activities and cooperative learning technique (Rao and DiCarlo, 2000; Lombardi and Oblinger, 2007). Teaching method like PI makes the students active in the class and aid students' high retention, but retention is low where students are passive. The reason is that they learned by memorizing to pass the examination. The conceptual framework in figure 1 below explains better.

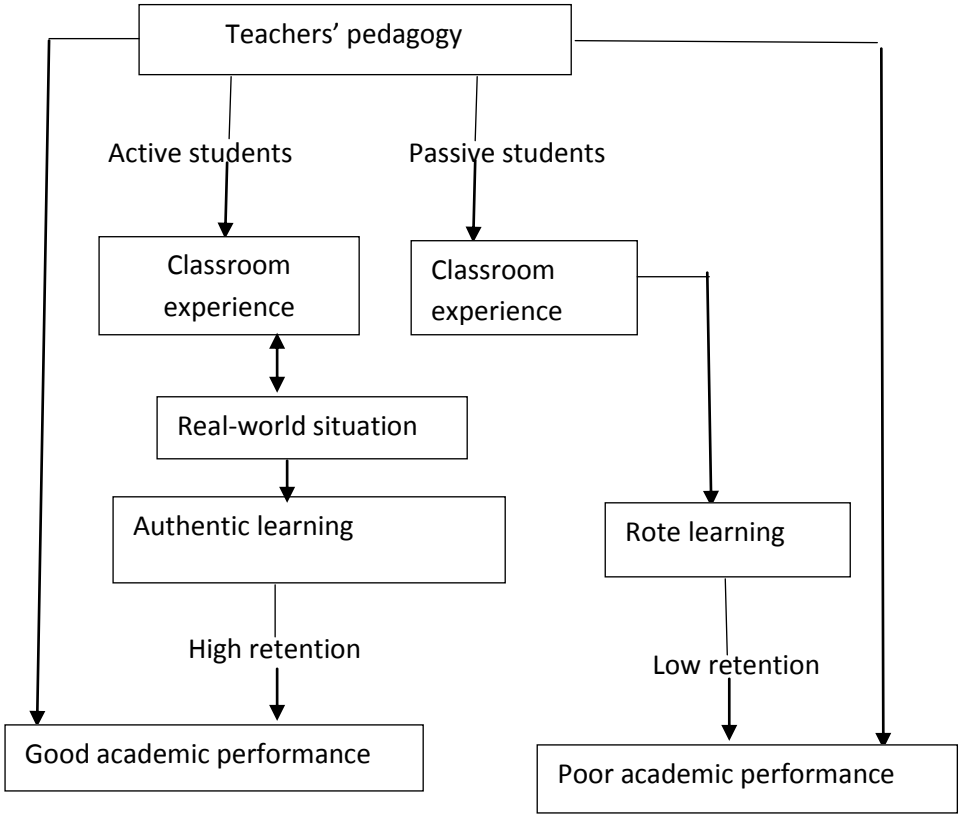

Figure 1: Conceptual framework of authentic learning and PI

The framework indicates both active and passive students had classroom experience. There is a link between active participation in the class and being able to solve real-world problems. On the other hands, when the students are passive it leads to rote learning. A student who can use what he or she learned to solve the real-world problem will always have a high retention. However, students who always learned by memorizing will have low retention. The result of high retention is good performance while poor performance is the result of low retention.
The next section of this paper is peer instruction. This section will describe in details the process and the implementation of PI.

PEER INSTRUCTION

Peer Instruction (PI) is a research-based pedagogy for teaching large introductory science courses Fagen and Mazur, 2003. It is a method created to help make lectures more interactive and to get students intellectually engaged with what is going on. It has been tested in many classes and found to be good for improving students' performance and also used to identify student difficult areas. PI has been used in different subjects in many countries. Peer Instruction is still a new method of teaching for teachers in many countries because of its unique feature of *CocepTest.*

Peer Instruction is an instructional strategy for engaging students during class through a structured questioning process that involves every student Crouch, Watkins, Fagen and Mazur, 2007). PI provide a structured environment for students to voice their idea and resolve misunderstanding by talking with their peer (Gok, 2012).

Peer instruction is a cooperative learning technique that promotes critical thinking, problem-solving, and decision-making skills (Rao and DiCarlo, 2000). Research shows talking to peers forced them to organize their thoughts and reminded them of the concepts they had difficulty recalling on their own (Gok, 2012). Peer Instruction is an interactive approach that was designed to improve the learning process (Rosenberg, Lorenzo and Mazur, 2006). This method have the advantage of engaging the student and making the lecture more interesting to the student. It also has the tremendous importance of giving the lecturers significant feedback about where the class is and what it knows.

PI is more effective at developing students' conceptual understanding than traditional lecture-based instruction (Lasry, Mazur and Watkins, 2008). According to Crouch, Watkins, Fagen and Mazur (2007), PI increases student mastery of both conceptual reasoning and quantitative problem solving. PI increase conceptual learning and traditional problem-solving skills (Lasry, Mazur and Watkins, 2008). According to (Gok, 2012). PI encourages students to take responsibility for their learning and emphasize understanding. Peer instruction increased student conceptual learning and performance on quantitative problem-solving questions. PI is not a rejection of the lecture format, but a supplement that can help engage students who have a range of learning styles (Rosenberg, Lorenzo and Mazur, 2006).

Peer Instruction involve students during class through activities that require each student to apply the core concepts being presented, and then to explain those concepts to their fellow students. Unlike the common practice of asking informal questions during a traditional lecture, which typically engages only a few highly motivated students. PI incorporates a more structured questioning process that involves every student in the class.

The goal of PI is to transform the lecture environment so that it actively engages students and focuses their attention on underlying concepts. Instead of teaching from the textbook or lecture notes, lectures consist of short presentations on the main points. Each followed by short conceptual questions called *ConcepTest*, typically posed in a multiple-choice format, on the subject being discussed. According to Turpen and Finkelstein (2010), Mazur describes the process of PI as:

1. The question posed
2. Students are given time to think
3. Students record or report individual answers
4. Neighboring students discussed their answers
5. Students record or report revised answers
6. Feedback to teacher: Tally of answers
7. Explanation of the correct answers

With using PI, the instructor starts with a brief presentation or summary of the material to be covered. After this, the instructor poses a *ConcepTest* and asks students to think about the question and related concepts. The instructor then allows 1–2 minutes for students to think and come up with an individual answer. This may be through clickers, flashcards, a simple raising of hands, or writing down the answer on a piece of paper. The instructor may revisit the concepts using lecture or try a different *ConcepTest* if too few students' responses to the answer are not correct. If a majority of students' responses is correct, the instructor will then give a brief explanation and moves on to the next topic or *ConcepTest*. In a situation where 30–70% of the students answer the concepts correctly, the instructor asks students to turn to their neighbors and discuss their answers. Students talk in pairs or small groups and are

encouraged to find someone with a different answer. The teacher move around the room to encourage productive discussions and guide student thinking. After several minutes, students re-examine the same concepts and the instructor then explains the correct answer. The instructor can pose other related concepts or proceed to a different topic or *ConcepTest* depending on the student answers. For a better understanding of the PI as a pedagogy of teaching, the conceptual framework in the figure 2 below will explain better.

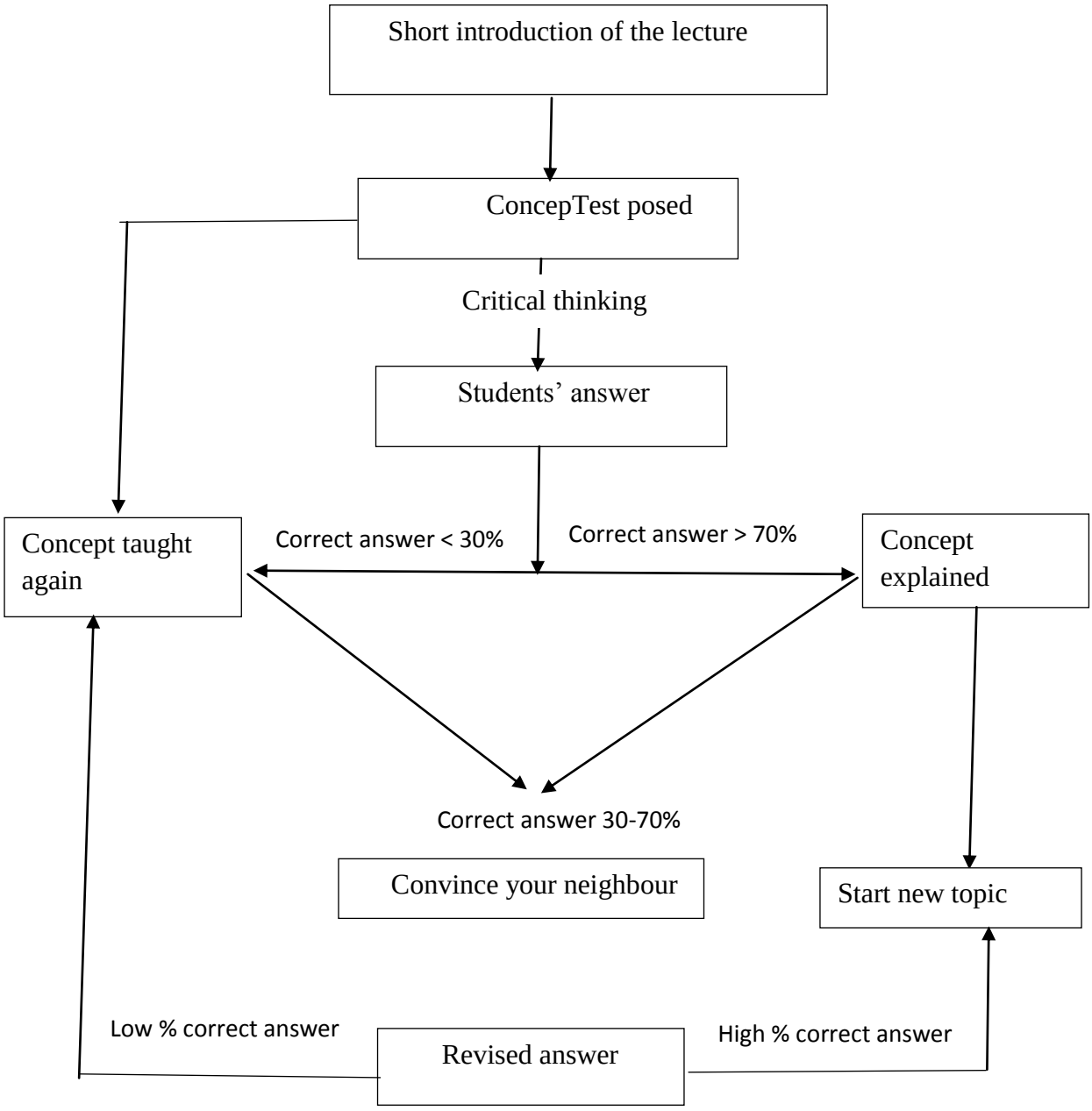

Fig. 1: Conceptual framework

CONCLUSION

Based on the above discussion, it is obvious that there are already known teaching pedagogies in science that actively engages students in the class. However, PI could be a better one based on various reviewed studies that PI is a teaching pedagogy that engages students in active learning through the use of *ConcepTest.* This pedagogy of teaching is still

new to many African schools and teachers. *ConcepTests* are described by Crouch, Watkins, Fagen and Mazur (2007) as the cornerstone of teaching with Peer Instruction. Apart from the use of *ConcepTest*, the period of "convincing your neighbor" is peculiar to PI, and it is the most important aspect of the PI. One major significance of PI is that students teach themselves with the best language they could understand. PI engages students during class through activities that require each student to apply the core concepts being presented. Moreover, then to explain those concepts to their fellow students (Crouch, Watkins, Fagen and Mazur, 2007).

PI has many advantages both for the teacher and the students if properly implemented. First and foremost, it has the advantage of ensuring no student is inactive during the lesson. One of the best ways to improve academic performance is to ensure no student is passive during the class activities. Experience has shown that participating in learning activity help student's memory.

Secondly, it enables the teacher to get instant feedback from the students about their learning. Feedback takes place when the students give an answer to the *ConcepTest* posted to the class. Feedback is very important in teaching and learning. PI assist the teacher to fix the learning problem, and remedial action is taken to help the students as the lesson is in progress.

RECOMMENDATIONS

The various literature reviewed confirmed the effectiveness of Peer Instruction in improving conceptual and problem-solving skill of the students. Therefore, it is suggested that research studies using PI in Nigerian schools at all levels should be carried out in science education to ascertain the veracity of its effectiveness.

It is also important to carry out studies using Peer Instruction to teach other subjects in both primary and secondary schools in Nigeria. This is necessary because almost all the studies carried out in other countries on PI was in higher education level.

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