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### Research Article

## Authentic Science Learning Experience in Nigerian Schools: A Desirable Education Reform in the 21st Century

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### Abstract

*The paper looked at the reform in the teaching and learning of science in Nigeria educational system because the present system lacked the authentic learning experience. The inability of the students to transfer theory to practice makes the system inadequate. The paper criticized the teaching strategies most Nigerian teachers employed in classes and put forward a more research-based pedagogy. Nine fundamental authentic learning elements were highlighted in the article. In other to achieve some of the elements the paper recommended peer instruction (PI) as a better method of teaching already implemented in many developed countries. The paper suggested a revision of the curriculum along the line of some of these authentic learning elements.*

**Keywords:** authentic learning, curriculum, dialogical argumentation, peer instruction.

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### Introduction

The present system of education in Nigeria is deficient of the authentic learning experience in all levels. The reason for this is not farfetched. Many of the graduates of Nigerian schools have the problem of transfer of knowledge because they learned by rote. This makes it difficult for most brilliant students to perform when they are employed in

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any organization or company after graduation. The question that needs to be asked is: what is the cause(s)?

The primary cause of this problem is that teaching in Nigerian school is teacher-centered popularly called lecture method. In this present day where there are agitations for inquiry method of learning students still, do not participate enough in learning. Teachers and all stakeholders in education have forgotten that the most important educational goals are to promote retention and transfer (Mayer, 2002). What is common in schools today is the only retention where students memorized facts and can recall. For students to be able to recall and transfer what was learned and used in a new situation, they must be actively involved in the learning process. Besides, some other elements are fundamental to learning that are often ignored by the teacher and the government. Therefore, if there is the need for education reform in the 21<sup>st</sup> Century, it must be based on education that promotes retention and transfer. This could only be achieved through an authentic learning experience in schools.

### **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, 2007). Students are actively working, participating in discussions, hunting for information, and enjoying the entire process of authentic learning (Mims, 2003). Authentic learning activities are designed to give the students 'real-world' experiences. Educational researchers have found that students involved in authentic learning are motivated to persevere despite initial disorientation or frustration, (Lombardi, 2007)

Authentic learning is learning by doing. It is active learning, where students are not passive. It is an inquiry method of learning. This is a process of asking meaningful questions, finding information, drawing conclusions, and reflecting on possible solutions (Milson, 2002).

Herrington and Kelvin (2007) contended that much of the abstract knowledge taught in most schools is not retrievable in real-life because it ignores the interdependence of situation and cognition. For this knowledge to be relevant and retrievable in real-life, the authors advocated for an authentic learning with the nine fundamental elements. The elements are authentic contexts, authentic activities, expert performances, multiple roles

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and perspectives, collaborative construction of knowledge, reflection, articulation, coaching and scaffolding, and authentic assessment. Each of these elements shall be reviewed fully.

### **Authentic contexts**

This is a situation that reflects the way the knowledge will be used in real-life. It is an authentic learning environment. An authentic learning environment establishes a sense of personal control over what and how the learner learns (Watters and Ginns, 2000, p. 307). Herrington and Kelvin (2007) contended that authentic contexts in the classroom are not just simple examples from real world practice that illustrates a concept to be taught. The authors concurred that authentic contexts must be all-embracing to provide the purpose and motivation for learning and complex learning environment that can be fully explored. A learning environment is similar to some 'real world' application or discipline: managing a city, building a house, flying an airplane, setting a budget, solving a crime (Lombardi, 2007, p. 2). Authentic learning environment must be a physical environment that mirrors the way the knowledge be used in real-life (Brown et al., 1989). Learning within a realistic classroom situation provides a useful real-life context for the students and compares favourably to their views of the alternative pedagogical methods they frequently encounter at university (Herrington and Oliver, 2000, p.35). Herrington (1997) recommended that an authentic environment should be a significant number of resources to enable sustained examination from some different perspectives.

### **Authentic activities**

Authentic activities or tasks reflect the kind of activities that people do in the real world, that are completed over a sustained period, rather than a series of shorter disconnected examples (Herrington and Kelvin, 2007, p. 5). According to Herrington (1997), any authentic task should have the following characteristics:

Ill-defined; promote exploration where students find as well as solve the problems; provide the opportunity to detect relevant and irrelevant material, and allow sustained thinking by exploring topics in depth (p.45). Authentic activities match the real-world tasks of professionals in practice as nearly as possible (Lombardi, 2007, p.3). Authentic activities comprise complex tasks to be investigated by students over a period (Herrington, Oliver, and Reeves, 2003, p. 63). Rule (2006) posits authentic activity as one component of authentic learning that is targeted towards a real problem, and that is having a possible impact outside the classroom.

### **Expert performances**

Expert performances and the modeling of processes, allow students to observe a task before it is attempted (Herrington, 1997, p. 48). Through the experts, students have the opportunity of comparing their performance, skills, and understanding with the expert in the field (Collins, Brown, and Holum). Authentic learning environments give students the opportunity to the expert thinking and performances, and this allows students to observe the task before it is attempted and to access the modeling of processes (Herrington and Kelvin, 2007). The expert's idea could be in the form of video movies of an expert in their professional field; opportunity for the sharing of narratives and stories (Brown, Collins and Duguid 1989). This idea is drawn from the apprenticeship system, where a learner is assigned to work with an experienced practitioner (Herrington, 1997).

### **Multiple roles and perspectives**

Instead of learning through interaction with a single perspective such as a teacher, an authentic learning environment provides the learner with the opportunity to investigate multiple ideas, roles, and perspectives (Herrington and Kelvin, 2007). Honebein (1996) defined multiple perspectives as a significant cognitive activity that should be promoted in the design of authentic learning environments. It allows different perspectives from different points of view; not just a single perspective- such as a textbook (Herrington, Reeves & Oliver, 2010). Multiple roles and perspectives allow different people, media and resources to be employed as required to provide a rich array of opinions and points of view (Herrington and Kelvin, 2007). Herrington (1997) recommended that it is important to provide the opportunity to crisscross the learning environment by providing more than one investigation within a resource sufficiently rich to sustain repeated examination (p.51).

### **Collaboration**

To ensure students learn in a way that will reflect the real-life situation there is the need for collaborative learning. Herrington (1997) pointed out that collaboration, and the opportunity to collaboratively construct knowledge is an essential ingredient of authentic learning. Collaboration is not just too ordinarily put the students in groups during learning. Collaboration is not working together in a group but solving a problem together. Herrington, Reeves and Oliver (2010) contended that the characteristics of a good collaboration are: team or pairs, not individuals; task-focused groups not individual; and encouraged through technology.

Katz and Lesgold (1993) succinctly argued that collaboration is more than cooperation because collaboration is synchronous, but cooperation may be synchronous or asynchronous. Collaboration allows students to 'put their heads together' on problems, and to fully articulate their progress as they go about the task (Herrington and Kelvin, 2007, p.9). According to Herrington, Reeves, and Oliver, collaboration provides joint problem solving and social support.

### **Reflection**

Reflection is those intellectual and affective activities in which individuals engage to explore their experiences to lead to new understandings and appreciations (Boud, Keogh, and Walker, 1985, p.19). According to these authors, reflection has three features which are, returning to the experience, attending to feelings and re-evaluating the experience. The need for reflection cannot be underrated in the learning of science. In support of this Herrington and Kelvin (2007) believed that learning opportunities in school are missed when students are not allowed to reflect upon and consolidate their learning. To reflect on their learning, the students should frequently return to the experience, recollecting the important considerations and relating them to their partners (Herrington and Oliver, 2000). Reflection is an opportunity to think about, reflect and discuss choices. There are reflections *in* and *on* learning. Reflection *in* learning is when choices are made during the learning while reflection *on* learning is choices made after the learning (Herrington, Reeves, and Oliver, 2010).

### **Articulation**

The process of articulating enables formation, awareness, development, and refinement of thoughts (Herrington, 1997, p.58). The students' opportunity to verbalize their thoughts in pairs allowed them to be aware of their learning and to make appropriate links to incorporate it into their cognitive frameworks (Herrington and Oliver, 2000). Articulation provides students with an opportunity to speak and write about their growing understanding (Herrington, Reeves, and Oliver, 2010).

Research studies show that student been able to defend his or her view in science through a logical argument is part of learning. Kuhn (2009) contended that the skills of the argument are fundamental intellectual skills, worthy of attention in science education. As an important aspect of scientific inquiry, argumentation plays a role in the generation and justification of knowledge claims (Erduran, Ardac, and Yakmaci-Guzel, 2006, p. 1). According to Kuhn and Reiser (2005), argumentation or persuasion has been seen to

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foster student engagement with the learning process and therefore engagement with the content under study. Articulation enables the student to be able to make a public presentation to defend his or her position and ideas (Herrington, Reeves, and Oliver, 2010).

### **Coaching and Scaffolding**

According to Rosenshine and Meister (1992), Scaffolding is a process in which students are given support until they can apply new skills and strategies independently. Authentic learning environment provides for coaching at critical times, and scaffolding of support, where the teacher provides the skills, strategies and links that the students are unable to provide to complete the task (Herrington, 1997, p.60). Scaffolding has some benefits to students learning: one of such benefits is that scaffolding instruction provides supportive learning environment (Johnston and Cooper, 1997). These authors said scaffolding learning environment provides students opportunity to ask questions, feedback and support their peers in learning new material. Scaffolding as a principle of effective instruction provides teachers the opportunity to accommodate individual student needs (Kame'enui, Carnine, Simmons and Coyne, 2002). Choi and Hannafin (1995), contended that coaching in an authentic learning environment requires a powerful, but different roles for the teachers.

### **Authentic assessment**

Authentic assessment is when the assessment is integrated with the task instead of separate testing (Herrington, Reeves, and Oliver, 2010). According to these authors, it implies seamless integration of assessment and task.

Young (1993) contended that assessment must become an integrated, ongoing, and seamless part of the learning environment. Gardner (1992) argued that formal tests and assessment materials are not sensitive enough to account for cultural differences, and they are rarely useful in determining students' level of competence.

Lajoie (1991) posited that more authentic assessment is required to assess the students' learning which they would carry out in the real world, as against the kind of tasks traditionally learned in classrooms. According to Herrington and Kelvin (2007), in an authentic learning environment, assessment should be seamlessly integrated with the activity, that is, students are assessed on the task they perform rather than with a separate test (p.13).

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Regardless of the subject matter, when the students are actively involved, they learn more and retain it longer than when they try to absorb knowledge passively (Green, 2003). Interest and achievement of students lie within the teacher and students' interaction/relationship in a given subject (Onah and Ugwu, 2010). Creating classroom environments that promote positive cultures with real interactions can motivate students to channel their energies and desires to reach their goals (Nugent, 2009).

Authentic learning means learning which happens by actually participating and working on real-world problems; it engages learners by the opportunities of solving complex real-world problems and finding out solutions (Har, 2013, p.1). Authentic learning is a concern with the experience of linking the real-world to the classroom (Hui and Koplin, 2011). To be able to connect what is learned in the classroom to solve the real-world problem there must be a higher retention. Meaningful learning should not be only to acquire knowledge but be able to apply the knowledge. Experience shows that learning in science is through memorization. Thus, the students are unable to apply the knowledge adequately outside the classroom (Mazur and Watkins 2009; Brown, Collins and Duguid 1989).

Meaningful learning occurs when students build the knowledge and cognitive processes needed for successful problem-solving (Mayer, 2002). It implies that students should be able to solve problems in a new situation different from what has been taught in the classroom. The most two important educational goals are to promote retention and to promote transfer (Mayer, 2002). The ability to remember what was learned at some later time in the same way as it was presented during instruction is retention. According to Mayer, transfer referred to the ability to use learned materials to solve new problems, answer new questions, or facilitate learning new subject matter.

Given the above background, the need for a research-based pedagogy is imperative. One of the sources of the problem of science teaching and learning in Nigerian schools is the issue of poor pedagogy. The kinds of students we have in schools today are not like the pre-independence and post-independence. Nigeria economy is growing, and so the population is growing too. Corresponding to this burgeoning economy and population is the technology. Students are not static in knowledge and therefore do not want to rely on giving information as done in the traditional lecture method. The present-day students need an activity-centred classroom where they could interact with peers and the teacher. They need a classroom where they could control what they learned not a curriculum-

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laden classroom. In other to support this, there is the need to consider some theories of learning before talking about teaching pedagogy.

### **Theory of Learning**

The theory is vital in educational research as the term is commonly used in papers, books and even doctoral theses (Tellings, 2012). According to Leedy and Ormrod (2005), the theory is defined as an organized body of concepts and principles intended to explain a particular phenomenon. The theory has many functions in educational research. Tellings opined that theory provides predictions and explanations as well as guidelines for actions and behaviour (p.4). The author further explained that theory provides a safeguard against unscientific approaches to a problem, an issue or a theme. Johnson and Christensen (2007), theory tells the why and how certain things in education functions in the way it functioned. In this write-up, the two theories considered are social constructivism theory (SCT) and constructive controversy theory (CCT) of learning.

### **Constructivism**

Constructivism emphasizes the importance of the knowledge, beliefs, and skills that an individual brings to the experience of learning (Garbett, 2011, p.37). There are both the philosophical meanings of constructivism, as well as personal constructivism within the contexts of education (Jones, 2002). The argument of cognitive constructivism is that knowledge is not directly transmittable from person to person, but rather constructed or discovered individually and idiosyncratically. Learner-centred and discovery-oriented learning processes are the major emphases of cognitive constructivists. According to Liu and Matthews (2005), in the process, social environment, and social interaction work merely as a stimulus for individual cognitive conflict (p.388).

Social constructivism derived from the work of Vygotsky emphasizes the important role of social environment in learning. Social constructivist believes student learned from his or her interaction with his or her immediate environment. In this view, learning is considered to be a situation-specific and context-bound activity (Eggen and Kauchak, 1999).

In this study, the more suitable among the two types of constructivism to the teaching pedagogy under consideration is the social constructivism derived from the work of Vygotsky. The next focus of the article is the social constructivism theory.



### **Social Constructivism Theory**

The social constructivism was developed by Vygotsky who argued that learning is a social and collaborative activity where people create meaning through their interactions with one another (Schreiber and Valle, 2013). Students created ideas through interaction with the teacher and other students. Interaction is very crucial to students' learning. Educause Learning Initiative (2005) argued that successful learning closely link to interaction. Learning is a process of interaction through which the learners develops their understanding by assembling facts, experiences, and practices.

For Powell and Kalina (2010), collaboration and social interaction are incorporated in social constructivism. This theory believes in the social interaction of students in the classroom along with the critical thinking process. Creating a deeper understanding of learning requires cooperative learning. These authors contended that social learning is a part of creating a social constructivist classroom. The theory believes that students have plenty to offer one another by not only working one-on-one with the teacher but also with other students.

According to Kim (2001), individual create meaning through their interactions with each other and with the environment where they live. The author argued that meaningful learning could only take place when students are engaged in social activities. Andrews (2012), social constructivism is concerned with the nature of knowledge and how it is created. Social constructivism believes that both the context which learning occurs and the social contexts that the learners bring to the classroom is crucial (Kim, 2001).

Social constructivism has a perspective that focuses on the relationship between people and their environment (Kim, 2001). This author believed students learned with their mind and at the same time interacts with the environment as learning is going on, it is, therefore, difficult to separate learning from the environment. Bredo (1994) noted that if the environment and social relationships among groups of students change, obviously the tasks of each student also change. Thus, Kim said learning should not and cannot take place in isolation from the environment.

### **Constructive controversy theory (CCT)**

The constructive controversy involves deliberative discussions aimed at creative problem solving (Johnson, Johnson, and Tjosvold, 2000). Students must be able collaborators, and follow the norms of cooperation and the rules of rational argumentation. Students are

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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.

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 agree on the best position based on evidence and reasoning (Johnson and Johnson, 2007). According to Daniels and Cajander (2010), constructive controversy builds 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 innovative and constructive thinking skills to find solutions to complex and challenging problems. The ultimate goal of constructive controversy theory is 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).

Numerous theories of learning in education could be considered for this study, but social constructivism and constructive controversy theories are considered the most appropriate for this study. These theories are active learning theories that considered students to be at the center of teaching and learning. Both theories considered students' interaction among themselves vital, and that constructive argumentation helps students develop their critical thinking ability. At this juncture, a research-based pedagogy will be discussed before the suggested reform.

### **Peer Instruction (PI)**

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 effective for improving students' performance and also used to identify students' difficulty areas.

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 provides a structured environment for students to voice their ideas and resolve misunderstandings by talking with their peers (Gok, 2012). Peer instruction is a cooperative learning technique that promotes critical thinking, problem-solving, and decision-making skills (Rao and DiCarlo, 2000) and it was designed to improve the learning process (Rosenberg, Lorenzo, and Mazur, 2006). PI helps the teachers and the students to identify and solve the problem of misconception in science (Aina, 2016).

PI is more efficient at developing students' conceptual understanding than traditional lecture-based instruction (Lasry, Mazur, and Watkins, 2008). According to Crouch, Watkins, Fagen and Mazur, PI increases student mastery of both conceptual reasoning and quantitative problem solving (Lasry et al., 2008). According to Gok (2012), PI encourages students to take responsibility for their learning and emphasizes understanding. It is not a rejection of the lecture format, but a supplement that can help engage students who have a range of learning styles (Rosenberg et al., 2006).

Peer Instruction engages 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. Lectures in PI consist of the short presentations on the main points, each followed by a *ConceptTest*. Concepttest is a short conceptual question, typically posed in a multiple-choice format, on the subject being discussed.

Discussion sections and homework are used to address the problem-solving ability of the students. The teacher will demonstrate to the students by solving a problem, and then students go into a group discussion. The teacher moves around to assist the students that may encounter any problems. At the end of the week, the students are expected to turn in their written solutions to the problems (Crouch, Watkins, Fagen, and Mazur, 2007).

The teacher gives reading assignments to the students. The importance of this is to ensure students do part of the work ahead of the lecture (Mazur, 1997). For the effectiveness of the reading assignments the teacher administers reading quizzes at the start of the lecture. The homework and reading assignments are an exquisite way of teaching the problem-solving skills in the PI class. However, ConceptTests are based on conceptual questions, the development of problem-solving skills is taken care of by the homework and discussion sections.

### **The Reform**

The present paradigm of teaching and learning in science needs to be reformed. Nigeria educational system since independence revolves around a particular pattern that requires reform. Nigeria education is defective in such a way that a Ph.D. degree holder could not rectify a problem in an organization after several attempts until an ordinary technician from another country came to solve the problem. The reform suggested here is based on the two constructs which are a pedagogy of teaching and the authentic learning. The two are joined, the first leads to the second.

### **Paradigm Shift in Teaching Method**

It is time to shift from the lecture method to a more research-based pedagogy of teaching. Some readers may spurn this suggestion say it is not new that most teachers are already moved away from lecture-based instruction. Perhaps they may mention some methods in vogue as inquiry, cooperative method, and the likes. These questions are germane: what are the learning tasks? Who dictate these tasks? Is it ill-defined? Does it promote exploration? Does it provide the students with the opportunity to detect relevant and irrelevant materials in learning? Is it targeted at solving the real problem even outside the classroom?

It is a pity that most so-called inquiry and the cooperative methods of learning practiced in schools today cannot answer the above questions correctly. The reason is that the learning tasks are guided by the curriculum designed by some people in the ministry of education. The task is well outlined without consideration to the need of the students.

The method of instruction should be purely students-centred where the students control their learning activities, not the curriculum. Coaching and scaffolding should be prevalent not where the teacher act as an authority who has all the knowledge. The students have the best language to teach themselves better than the teacher. The students' brain are not a blank slate: they possess knowledge on which they can start to construct new one which allows them to build a lifelong knowledge by themselves. This is the point Vygotsky made in social constructivism. The students' opinion in learning should not be suppressed: allow them to argue their views among themselves through dialogical argumentation. The constructive controversy theory emphasized the need for students to have the opportunity to argue on a conflicting issue in learning and come to a consensus.

We need teaching methods that allow students maximum social interaction and allow the students freedom to discuss freely on their learning. Peer Instruction is a research-based pedagogy that has been implemented in many developed countries and tested in a school in Nigeria. The method gives hundred percent social interaction among the student and allows students to discuss on their learning freely. It also yields amazing results on students' academic achievement. More importantly, it makes the students be lifelong learners who can transfer theory to practice. Aina (2016) in a paper "Using peer instruction (PI) to investigate pre-service teachers' academic performance in Nigeria" recommends PI for science teachers based on findings of the study.

PI is an innovation in education. It has implications for both the students and the teachers. Implementing PI require teachers that are adequate in pedagogical content knowledge (PCK) and high teacher self-efficacy. Self-efficacy is the belief a teacher has about his or her ability to accomplish a specific teaching task (Lunenburg, 2011). Pendergast, Garvis, and Keogh (2011) said teachers with a high level of teacher self-efficacy have been shown to be more resilient in their teaching and likely to persist in a difficult time to help all students reach their academic potential. ConcepTest is a cornerstone of PI (Crouch, Watkins, Fagen, and Mazur, 2007); designing good and appropriate ConcepTest demand that a teacher has sound PCK. Besides, creating a library and databases for ConcepTest as done in the developed countries where PI had been adopted demands many things from the teachers and the government. Once the issue of teaching method is solved, addressing other areas of the reform is made easy such as strengthening students' collaboration, articulation, and multiple role and perspective in learning.

Our education should allow more of collaboration among students rather than cooperation. In collaboration students work on the same task for a particular period, there is no division of labour in collaboration. However, in cooperation, students breaks down a concept into parts and give each part to the different student to work on as a division of labour. Collaboration is not working together in a group but solving a problem together. Herrington, Reeves, and Oliver (2010), collaboration has the characteristics of teamwork, or pairs not individuals and task-focused groups not individual. We should tailor our education towards enhancing higher collaboration instead of individualistic learning approach.

Nigerian students are gradually losing interest in schooling because learning is no more fascinating. This is evidently clear at the rate of indiscipline and academic failure among

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students in Nigerian schools today. To reawaken the student's' interest in schooling, we must embrace the social constructivism and constructive controversy theories in classes. Through this, students become active learners who fully participates in learning where the three domains of learning are evident by collaboration. Collaborative learning could help bring back the lost interest in schooling. Through the collaboration, learning is made authentic because such learning has higher retention by the students (Aina, Aboyeji, and Aboyeji, 2015). Collaboration promotes articulation.

Students' articulation should be strengthened in our education because of its importance in achieving authentic learning experience. When students are permitted to verbalize their thoughts in pairs, it makes them aware of their learning and incorporates it into their cognitive frameworks (Herrington and Oliver, 2000). Students should be able to speak and write about their understanding through articulation. It is part of learning for the students to be able to defend his or her views or opinion through a logical argument. The submission that the skills of the argument are fundamental intellectual skills that should be imbibed in science education (Kuhn 2009) is true.

Multiple roles and perspectives in learning need to be taken seriously in our education. The major resources for learning in Nigerian schools are the textbook and the teacher. Students should have many resources through which they could learn. Many schools and universities in Nigeria have poor internet connectivity. Students should be able to access their learning on the web anywhere in the school. Multiple roles and perspectives allow different perspectives from different points of view; not just a single perspective- such as textbooks.

The idea of resting solely on the teacher and the textbooks for learning should be discouraged. Students should be provided with different perspectives for their learning. In other to do this, students should be able to investigate issues from more than a single perspective (teacher or textbook). It is important students explores different perspectives, for example, Google and research databases. Schools must have functional internet connectivity and subscribe to databases like EBSCO, ERIC, Google Scholar, WorldCat, INOMICS, Universe Digital Library and much more. Many schools including universities in Nigeria do not have any useful database where students can access information relevant to their learning.

There is a particular University in Southern Africa where one can remain in a lecture room for a whole day browsing through databases gathering information about learning without any interruption. Through this, no student is limited to only what the teacher says or the textbooks.

Students at all level must be trained on the use of web resources for learning. The use of the Web should be in science curriculum: where all students are taught how to access World Wide Web (www). Many university students in Nigeria cannot access information on an email address box. This is very strange when the vogue in the most developed countries now is mobile learning. In other to make learning real in life situation, learning cannot be restricted to the classroom. Thus mobile learning is important.

It is true that the internet is full of good and bad information that may not be helpful to students' learning. Yes, that should not deter the use of it, even life itself is a hodgepodge of good and bad, yet we all cherish it. The use of the World Wide Web should not only be learned by those who are in computer science related courses. It should be compulsory for all students from the primary school.

Collaborative learning must be at the center of the schooling in Nigeria. Collaboration as already discussed is a mutual engagement of students in a coordinated effort to solve a problem together. The students worked synchronously to create a product that could not have been achieved independently by either individual. Collaborative learning makes learning interesting to students because they learn by themselves exploring the perspectives of other group members. It makes them curious in their learning and all the time engaged in meaningful activities. Through this, they are a safeguard against the current brouhaha emanating from the student unrest in schools.

Science curriculum should be revised to make learning context reflects the way the knowledge will be used in real-life and learning tasks reflect the kind of activities that people do in the real world. We should stop deceiving ourselves with the curriculum-laden activities that lead to nowhere but ends in the classroom. The curriculum should dwell much on evolving the dialogical argumentative ability of the students. The argument in science learning helps the student to articulate their understanding. It is hard for students to forget any conclusion reached through a dialogical argument easily.

There is an increasing call across the world to incorporate ideas about how an argument can contribute to the process of scientific knowledge construction (Jimenez-Aleixandre and Erduran, 2007). The agitation to incorporate argument into the students' learning of science has not yielded a significant result. Nevertheless, the effort of Spanish National Curriculum; the Turkey National Reform; the Harari Report in Israel; the Curriculum Council of Western Australia; Chilean National Science Curriculum (Jimenez-Aleixandre and Erduran, 2007) are worthy of emulation.

Finally, reform in science teaching and learning is desirable for a sustainable education in the 21<sup>st</sup> Century. Nigerian science students should stop learning by memorization instead learn and retain what was learned and be able to transfer the knowledge for use in new situations. In other to achieve this the above reform in science teaching and learning is desirable in Nigeria educational system.

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