9

The Constructivist Physics Teacher

By

Okon Akpakpan Udoh
Directorate of Continuing Education,
Akwa Ibom State College of Education,
Afaha Nsit.

Abstract

The paper x-rays the kinds of changes needed by (physics) teachers to make a transition from the traditional forms of instruction to the constructionist instructional pedagogies. It examines the major characteristics of a constructivist classroom and the unique attributes of a constructionist (physics) teacher. It observes that a constructionist classroom is exemplified by inquiry oriented pedagogies leading to student-centred instruction in a democratic environment that promotes and enhances autonomous and self-regulating students. It portrays the constructivist teacher as a facilitator, guide, coach, mediator and consultant. Because the constructivist teaching is powerful in helping to achieve desirable educational goals for learners, (physics) teachers should be made to grow professionally towards a constructivist practice.

One of the prominent areas of education which has attracted the attention of educationists in recent decades is the process of making the teaching-learning situation easy for both the students and teachers. Educational curricular and teaching methods, including assessment modes are changing. One component of the current redevelopment of school curricula is the change in focus from the transmission curriculum to a transactional curriculum. To meet up with this development there is a shift from the behaviourist method of direct approach to teaching – such as in the lecture method, note copying and dictation, where the learner is give contents to memorize and regurgitate – to the constructivist instructional model, which is transactional. Senior secondary physics curriculum is not left out of this change.

The Senior Secondary Physics Curriculum

Physics is the study of natural phenomena at its most fundamental level. It is concerned with matter and energy; and the relationship between them (Awe &

Okunola, 1992). Physics is crucial for effective living in this modern age of science and technology. Given its application in industry and many other professions, it is necessary that every student is given an opportunity to acquire it concepts, principles and skills.

The objectives of physics education at the secondary school level are to (Obioma, 2009):

1 Provide basic literacy in physics for fundamental living in the society.
2 Acquire basic concepts and principles of physics as a preparation for further studies.
3 Acquire essential scientific skills and attributes as a preparation for technological application of physics, and
4 Stimulate and enhance creativity.

To ensure successful implementation of the physics curriculum, Obioma (2009) furnished teachers with the recommended strategies. His words:

> *… the guided-discovery method of teaching has been recommended, all in an effort to achieve the stated objectives of curriculum. In order to stimulate creativity and develop process skills and correct attitudes in students, the course is student-activity oriented with emphasis on experimentation, questioning, discussion and problem-solving. The introduction of the theme: "physics in technology" provides an opportunity for the construction and operation of workable devices as well as acquaintance with some products of modern technology.*

Analysis of these recommended strategies for achieving the objectives of senior secondary physics education will produce several instructional pedagogies required to make senior secondary physics more efficient for teachers and more productive for students. These pedagogies are (i) guided-discovery method (ii) inquiry approach (iii) process-based teaching method (iv) collaborative learning (v) discourse and reflective thinking. Let us highlight each of these methods.

The Guided-Discovery Method

Guided-discovery method is a student-centred, activity-oriented, ego-motivated teaching approach in which the teacher guides the students to find out things, validate knowledge and make discoveries, using the processes of science (Udoh, 2005). This way of learning through processes, according to UNESCO (1987), requires students to have opportunity for activities, seeking evidence through their own senses. Bajah (1983) averred that a teacher should be seen as a person who provides learning opportunities and necessary guidance for the students.

Inquiry Approach

This is a natural extension of the discovery approach. "It requires designing instruction so that as much learning as possible takes place in the context of answering questions and solving problems" (Prince & Felder, 2006). In pursuing answers, students usually start with exploration of materials, followed by a discussion of their discoveries. Often, new questions arise; students seek answers, leading to additional student-motivated inquires with materials to reinforce and extend concepts, processes and skills.

Process-Based Teaching Method

Process-based approach lays emphasis on helping students to develop process skills through hand-on activities. Students investigate, experiment, gather data, organize results, and develop conclusion based on their own actions.

Collaborative Learning (Student-to-student Interaction)

Collaboration is central to physics education. Students work in small groups, each member contributing to data collection, data analysis and reporting of results.

Discourse Pedagogy

Discourse is a tremendous exercise for the mind. It takes several forms: focused discussion in small collaborative groups, traditional whole-class question-and-answer sessions, content/inquiry sessions wrappings up segment of a given investigation.

The latent message in this analysis/highlight is that: to achieve the stated objectives of senior secondary physics education, a physics tacher requires a combination of instructional pedagogies which epitomize the constructivist teaching and learning approach.

The Concept of Constructivism

Constructivism is a psychological theory of knowledge which holds that individuals actively construct and reconstruct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences. Being associated with powerful teaching and learning, the main propositions of constructivism are that:

i Productive learning means personally constructing, creating, inventing, generating and developing knowledge.

ii New information is filtered through mental structures (schemata) that incorporate the students' prior knowledge, beliefs, preconceptions, misconceptions, prejudices, and fears. If the new information is consistent with those structures, it may me integrated into them, but if not, it is unlikely to be truly incorporated into the individuals belief system (Prince & Felder, 2006).

iii It is in the process of new knowledge construction that the old ones are refined, reformed or dropped (NTI, 2007).

The Constructivist Philosophy

The constructivist (physics) teacher believes that (Jonassesn, Peck & Wilson, 1999; Savery & Duffy, 1995):

a Knowledge is constructed, not delivered or transmitted.
b Knowledge construction results from activity; so knowledge is embedded in activity.
c Knowledge is anchored in, and indexed by, the context in which learning activity occurs.
d Meaning is in the mind of the knower.
e Cognitive conflict stimulates learning; meaning-making is prompted by a problem, question, confusion, disagreement or dissonance.
f Prior knowledge and experiences are crucial determinants of the nature of the learners' new knowledge and understanding.
g Productive learning is interactive, collaborative and cooperative.
h There are multiple perspectives on the world.

The Constructivist Classroom

The classroom is where the constructivist philosophy and practice meet reality. A constructivist classroom is exemplified by the following attributes: learner-centred instruction in a democratic environment; interactive, collaborative and cooperative learning in which the learner is given ownership of the problem and solution process; self-controlling and autonomous learners who use science process skills to test their scientific ideas against those of others in order to reach new understanding; learners who are participants in decision-making about learning; teachers who assume multiple roles, such as: a facilitator, guide, coach, mediator and a consultant.

The Students-Centredness

A productive, constructivist classroom consists of learner-centred, active instruction. In such a classroom, the teacher provides the students authentic experiences with which students are opportuned to observe carefully, pose questions, hypothesize, manipulate objects, extrapolate, predict, research and discover facts, concepts and principles for themselves. Accordingly, the constructivist teacher provides tools such as problem-solving and inquiry-based learning activities with which students formulate and test their ideas, draw conclusions and inferences.

Constructivist activities range from very simple to sophisticated and even complex tasks, depending on the teacher's learning objectives. If a teacher were to device a constructivist activity, the first thing he or she would have to do is to establish

an educational objective. The teacher would then need to think of a meaningful activity which would, at the same time, help students to reach the objective and to explore and construct new knowledge based on their previous knowledge. The teachers' role is to facilitate the process. In addition, the teacher is required to provide scaffolding which is "extensive support or guidance when students are first introduced to a method, followed by gradual withdrawal of the support as the students gain more experience and confidence" (Prince & Felder, 2006). These support can take the form of prompts, hints, suggestions on performing tasks that the learners could not execute (NTI, 2007).

As an illustration, consider this scenario: A group of students in a science class are discussing a problem (verification of ohm's law) in physics. Though the teacher knows the answer to the problem, she focuses on helping the students restate their questions in useful ways. He/she prompts each student to reflect on and examine his or her previous knowledge in the light of the current one. When a student comes up with the relevant concept, the teacher seizes upon it, and indicates to the class that this might be a fruitful avenue for them to explore. Facilitated by the teacher, the students design and perform relevant experiments (based on the objective of the lesson – verification of ohm's law, in this case). Afterwards, the students and the teacher discuss what they have learnt, finding out how students experimental results can help them to better understand the law under investigation.

The Process Approach

Fundamentally, the constructivist strategies and activities involve a process approach to learning. The process approach, according to National Teachers Institute, NTI (2000) are: observation, classification, communication, counting numbers, measurement, raising questions, formulating hypotheses, prediction, making operational definitions, controlling or manipulating variables, experimenting, data collection, interpreting data, inference, and manipulating apparatus.

A constructivist teacher believes that, if you give a person a fish, you are feeding him or her only once; but if you teacher the person how to fish, you are feeding him or her for life. Thus, instead of emphasizing the products of science (namely, accumulated concepts, theories principles and laws) – which would tantamount to making the students perpetual consumers of knowledge – a constructivist teacher focuses on exposing students to the processes of science to generate those products of science. Hence, the process approach encourages active participation of students in the learning process. Rather than being passive receivers of knowledge generated by others, the students are actively constructing and validating knowledge.

The Collaborative and Cooperative Learning

Learning is enhanced by social interaction, which is why a constructivist teacher encourages students to verbalize their thinking and refine their understanding by comparing them with those of their peers. Authentic student-student and student-teacher dialogue is very important in a constructivist classroom. The teacher helps the students to construct knowledge by guiding their learning in a collaborative group setting. When students collaborate, they share the process of knowledge construction, rather than labour individually. "Collaborative learning enables students to take responsibility for their own learning and develop strategies for learning" (Ogunkule & Gbamanja, 2006); Domination is absent, while reciprocity and cooperation are prominent.

The Negotiation Aspect

Negotiation plays a significant and prominent role when instruction is based on constructivism. In constructivist epistemology, 'negotiation' pertains to a rejection of the common practice of telling students what to do; it is a paradigm of trust in students, allowing them to be involved in decisions about their learning. Negotiation generates learner's sense of ownership of, and commitment to, authentic tasks. Physics teachers are expected to encourage students to accept responsibility for their own learning. This is achievable by: (i) negotiating the setting of goals in a collaborative and supportive environment. (ii) negotiating the nature of assessment tasks and the ways in which the tasks will be conducted. Negotiation is a form of empowerment for students and a way of developing learners responsibility.

The Democratic Practices

Arising from the philosophical paradigm of constructivism which stresses the socio-cultural construction of knowledge and negotiation of goal-setting as part of constructivist epistemology, the constructivist physics teacher demonstrates the following democratic classroom practices.

i Accommodating individuals and facilitating small-group and occasionally whole-class discussions.

Ii Creating empowering environment that supports interactive, cooperative learning behaviours such as exchange of ideas and opinions; sharing of responsibility and decision-making about learning; and demonstrating mutual respect.

Iii Supporting and promoting the concept of a classroom as an autonomous community that is self-regulating, rather than overtly controlling the students.

Power Wielding and Classroom Control

Closely related to the democratic quality of constructivism is the issue of power wielding and classroom control. The constructivist physics teacher is primarily concerned with students' empowerment through the provision of authentic leaning tasks with which students will acquire skills and abilities to be confident, autonomous and controllers of learning. Continually encouraging students to ask potent, probing questions is an integral part of the empowerment process. From a constructivist perspective, rather than asking students all the questions, a teacher should explore ways of getting students to ask thought-provoking questions.

In a constructivist approach, the teacher relinquishes power and classroom control to students. Nevertheless, neither the teacher nor the classroom is out of control – the teacher's power and control are now transformed into teacher's motivational encouragement of self-regulation of autonomous learners who are actively and fully engaged in assigned responsibilities.

Constructivism – Based Assessment

The constructivist mode of assessment is an innovative but objective and valid way of assessing the course of instruction as well as the learning outcomes of students. It lays emphasis on the provision of opportunities for teachers and students to negotiate the nature of assessment tasks and the ways in which the task will be conducted. Thus, unlike the traditional approach to assessment, it permits the learners' participation in his/her own assessment, in order to support, motivate and enable him/her to want to learn, to actually learn and to steadily make learning progress. "The role of the assessor becomes one of entering into dialogue with the persons being assessed to find out their current level of performance on any task and sharing with them possible ways in which that performance might be improved on a subsequent occasion" (Holt and Willlard-Holt, 2000).

Summary/Conclusion

Constructivism transforms the students from being passive recipients of information to active participants in a collaborative and cooperative learning process. Students construct their knowledge actively rather than mechanically injesting knowledge from the teacher. The constructivist physics teacher functions more as a facilitator who coaches, mediates, prompts, and help students to create and build meaning and knowledge. The critical goal is to wean the students away from dependence on instructors as primary sources of required information, helping them to become self-learners.

Adopting a constructivist approach to teaching will lead to better learning and more satisfied students. At the same time, it increases the effectiveness of the teacher in

terms of promoting his/her communication power and ability to create flexibility inorder to cater for the needs of all students, irrespective of socio-cultural backgrounds. Thus, the learning relationship in a constructivist classroom is mutually beneficial to students and teachers. Nonetheless, a constructivist physics teacher takes pride in his or her student's accomplishment rather than credit.

Implications and Recommendations

The constructivist physics teacher emerges as a guide, facilitator, mediator, coach and consultant with a philosophical underpinning of critical concepts such as (i) scaffolding (ii) process approach (iii) prior knowledge (iv) collaborative authentic tasks and (v) democratic principle. This scenario has fascinating implications with associated recommendations.

(i) To implement a constructivist approach to teaching, teachers should first be competent in best practices such as the provision of scaffolding to students which by definition, is a fairly high level of unavoidable support and guidance, from the teacher to the student, which should be, gradually withdrawn and faded as the learners performances increases, especially towards the later part of executing a task.

(ii) The process approach to teaching physics focuses on the need to learn 'how' rather than learn 'that'. Teaching, therefore, should be directed towards helping learners develop concepts rather than learn facts. Opportunity for practical experiences of genuine scientific investigations should be provided in order to develop students' conceptual understanding.

(iii) Social constructivism stresses the importance of learning activities building upon and respecting learners' prior experiences. The socio-cultural perspective of learning reminds us of a typical physics classroom in which learners bring along a range of varied experiences which should be recognized and valued. This implies that multiple learning activities should be deployed to accommodate the variety of learners need, interest and socio-cultural backgrounds.

(iv) A distinctive feature of constructivism is the use of authentic learning tasks which require understanding similar to those encountered in real-life outside the classroom. Many abstract concepts can be made realistic by embedding them in authentic tasks. The implication is that learning materials should be presented in the context of its intended real-world applications, taking cognizance of their relationship to other field of knowledge, rather than being taught abstractly, without context.

(v) The democratic nature of a constructivist classroom supports and promotes activities that are interactive and student-centred, anchoring on a facilitation-process of learning in which students are encouraged to be responsible and autonomous. It is exemplified in cooperative and collaborative learning

activities which provide simple opportunities for (students) interaction in a variety of ways, engaging them (student) in a reciprocal exchange of feedback which enhances the development of learning skills.

(vi) Constructivist teaching requires intelligence, creativity, patience, responsiveness, including ability to induce learners to construct knowledge for themselves, adjusting or rejecting their prior beliefs and misconceptions in the light of the evidence provided by experiences.

(vii) Because constructivist teaching is powerful in helping to achieve desirable educational goals for learners, teachers should be made to grow professionally towards a constructivist practice. Accordingly, physics teachers need to be provided with the opportunities, resources, support, encouragement and recognition in their professional development pursuits. Nonetheless, teachers should not be oblivious of the fact that the responsibility for professional development of teachers falls largely on the teachers themselves. Generally, professional development is an evolving, personal developmental process that in itself is constructivist.

References

Awe, O.& Okunola, O. (1992). *Comprehensive Certificate Physics.* Ibadan: University press Plc.

Bajah, S. T. (1993). *Teaching Integrated Science Creatively.* Ibadan: Inter Printing Press.

Calkins, L. (1986). *The Art of Teaching Writing.* Portsmith, N. H: Heinmann.

Holt, D. G. & Willard-Hort, C. (2000). Lets' Get Real-Students Solving Authentic Corporate problems. *Phi Delta Kappan,* 82, (3).

Jonassen, D. H; Peck, K. L. and Wilson, B. G. (1999). *Learning with Technology. A Constructivist Perspective.* New Yersey: Prentice Hall.

NTI, (2000). *NCE/DLS Course Book on Primary Education Studies Cycle 2, Modules, 1,2,3,4.* Kaduna: National Teachers Institute (NTI).

NTI (2007). *Social Studies*. Kaduna: National Teachers Institute.

Obioma, G. (2009). *Federal Ministry of Education Secondary School Curriculum: Physics for Senior Secondary Schools.* Abuja: Nigerian Educational Research and Development Council (NERDC).

Ogunkunle, A. R. & Gbamanja, T. S. P. (2006). Constructivism: An Instructional Strategy for Sustaining Students Self-Concept in Secondary School Mathematics. *Journal of Science Teachers Association of Nigeria,* 41 (1 & 2).

Prince, M. J. & Felder, R. M. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education,* 95 (2).

Savery, J. R. & Duffy, T. M. (1995). Problem-Based Learning: An Instructional Model and Constructivist Frame Work. *Educational Technology,* 35 (5).

Udoh, O. A. (2005). The Nigerian Physics Teacher. *Journal of Sustainable Education,* 1 (2).

UNESCO (1987). Primary Science Teachers Training for Process-Based Learing. *Report of the Workshop Held in Barbados, Common Wealth Secretariat,* 31st August – 9th September.