CONSTRUCTIVISM AND LEARNING IN SCIENCE

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Abstract

One of the most current theories of learning in science revolves round the concept of constructivism. The latter presents an argument that in science, children often learn via the process of conceptual change, which requires their being exposed to their pre-existing ideas or knowledge. Children are also willing to appreciate and explore personal theories, which they accumulate, from learning environment prevailing in their classroom. Teacher's classroom behaviour and the content knowledge taught by them affect what and how their students learn. Conceptual changes are often seen as a learner's transformation of personal intuitive idiosyncratic knowledge to scientifically 'correct' knowledge. Personally constructed meaning vary between individuals and are generally usually at variance with the received orthodox school science. In this paper, an effort has been made to examine the main features of the constructivist epistemology and how learning in science is affected among children. Research evidences have been presented and discussed to show that learners actively construct their own individual meanings in any situation - lecture, text, content, discussion, physical experiments etc. Implications of the constructivist view of learning in classroom science teaching and learning in our schools have been presented.

Introduction

It is not an entirely new theory that learning involves an active process of building knowledge structures. During the first quarter of the twentieth century, Jean Piaget developed an epistemological viewpoint, which stressed the need to identify and study children's cognitive structures and thus generalize across situations the learning of new concepts or tasks. (Piaget, 1929). Since the late 1970's however, there has been a growing number of science education researchers who have exhibited intense interest in and, commitment to focusing attention on content and content specific learning in science (Driver & Oldham, 1986). Efforts in this direction have led to current perspectives about learning which claims that learning involves an active process whereby a learner actually construct meanings from learning experience. The latter could be a text, classroom lesson, physical experiments or any other instructional transaction that generates a learning situation. This view of learning is rooted in a constructivist epistemology. (Weber, 1949, Von Glasersfeld, 1989). Constructivism revolves round the claim that, individuals usually construct meanings in their attempt to make sense of the world around them. The understanding an individual derives from a learning situation depends on both the incoming ideas/knowledge and the individual organization and deliberate restructuring of his pre-existing conceptual framework. (Driver, 1986a; Tobin, 1990).
In education, learning can be seen as a relatively permanent change in behaviour that is not due to maturation or the effect of drug but due to experience. The view of the nature of learning in science education under a constructivist perspective is a little different. Within a constructivist epistemology, learning can be defined as an interpretive process whereby an individual constructs knowledge by giving meaning to sensory data based on his prior knowledge or ideas (Tobin, Kahle & Fraser, 1990; Driver & Erickson, 1983). Learning thus involves constructions of individuals and social collaboration in which case knowledge is 'created' or 'constructed' through social interaction. The latter is actualized when the individual makes effort to ascertain the fit or usefulness of his conceptual understanding of the prevailing phenomena. Such interaction is usually done with others and in the context in which the knowledge created is applied (Driver, 1986b; Tobin, et al 1990; Asoko, 1996 & Appleton). Scholars who share the constructivist viewpoint claim that what a learner is already thinking (or already knows i.e. prior knowledge, ideas) has a significant effect and bearing on how s/he interacts with ideas being taught. Consequently, it is argued that these prior thinking has a determining role in subsequent learning. As has been observed and argued by Magoon (1977) and Driver (1986b), Piaget's theory of intellectual development could be said to be rooted in a constructivist epistemology. This is in view of the fact that Piaget was primarily concerned with how children construct knowledge and the use of 'self-regulation' process in individual learning. There is no doubt however, that Piaget's contribution to teaching and learning in both science and mathematics has been far reaching even the past three decades.

**Constructivism in the Learning of Science**

Within the study of science, there appears to be two major kinds of activities engaged in by all: the cataloguing of experiences with phenomena and, efforts made by humans to impose some regularity on experience through the creation of models or theoretical principles. Formal learning of science involves studies of natural world and theoretical principles and entities that have become generally erupted within the scientific community. This is the science usually referred to as school science; it comprises facts, concepts, relationships, principles and generalizations. There is however a growing evidence to show that children as individuals possess 'constructed ideas' which are in themselves based upon their individual idiosyncratic interpretations of sensory impressions. It is these 'personal' interpretations that influence how they respond to and understand science knowledge that they encounter inside the classroom. This situation is possible because if has been empirically confirmed that learners possess intuitive ideas about natural phenomena and, these ideas are not easily 'surrendered'. (Hewson, 1981; Osborne & Wittrock, 1983; Pope & Gilbert 1983; Driver, 1986; Shymansk, 1992; Okebukola, 1997). Furthermore, these Individual ideas result in personally constructed meaning, which we can refer to as conceptual structure or conceptual framework. This is the heart of the constructivist epistemology in which it is claimed that learners learn by actively constructing meaning from their experience. According to Driver & Erickson (1983), conceptual framework means the mental system of organization which an individual imposes on his/her sensory inputs and which is indicated in his/her responses to specific problems or problematic situations.

Novak (1987) posits that learners construct or build meaning into ideas, experiences or events in an effort to make sense of them. In such an effort, the learner's prior-knowledge is of significant value. It is not surprising therefore that, while constructivism recognizes the importance of assimilation or accommodations in the learning process, it places greater importance on prior context and content specific ideas/conception. In an attempt at delineating the basic characteristics of the constructivist view of learning, Driver (1986a) observed that it is a tradition
that

... is concerned with the intents, belief and emotions of individuals as well as their conceptualizations and which recognizes the influence that prior experience has on the way phenomena are perceived and interpreted... (pg.2).

The preceding observation was borne out of the understanding that what a learner is already thinking has a pivotal role and influence on how s/he would interact and react to teaching-learning situations. Such prior-ideas also exert a domineering role in subsequent learning (Abimbola, 1987; Johnson & Gott, 1996). It is a key feature of the constructivist viewpoint that these mental constructions or 'schemes' are used by the learner to understand and interpret new situations. Learners do not just receive or absorb what they are given, either in the form of teaching, or reading of a text or exposure to experiment? situations. It can be succinctly put therefore that, what a learner actually rests on a two-legged 'chair' which features: the characteristics of an incoming situation on the one hand and, the learners... 'schemes' or prior-conceptual knowledge on the other hand. This makes learning in science to be an active interactive process: an interaction between the learner's mental schemes and features of his learning environment.

The reality of the constructivist view of learning was made public from research findings reported in the several investigations on children learning by Osborne & Freyberg, (1985); Driver & Oldham (1986), Driver (1986a); Shmansky, (1992); Duit (1995) and Johnson & Gott (1996). In one of the latter's reports, one of the children was quoted and saying what most of her colleagues had verbalized. According to her, "... you know, teachers have got all that science knowledge but we are thinking about it differently because there are so many ways you can take something in..." (Osborne & Freyberg, 1985, pg.5). Thus, humans are 'knowing beings' and, the knowledge they possess and the type of organization they put into it have great impact on their actions, behaviours and interactions.

Driver & Bell (1986) have outlined basic characteristics of the constructivist perspective of learning in science. These include the fact that:-

1. Learning outcomes depends on both learning environment and on what the learner already knows; thus, the conceptions, purposes and motivations of the learner influence the way she/he interacts with materials.

2. Learning primarily entails an active construction of meaning. Learners do construct meaning by creating relevant links between their prior-knowledge/ideas and the new information they are faced with.

3. Learners' construction of meaning is both continuous and an active process. The learner continually re-examines the constructed meaning and make modifications in the face of new evidences or reconstructions.

4. Learners are responsible for their own learning. This is a necessary condition for meaningful learning and, the learner does this by directing his attention to the object of learning while at the same time making use of his prior knowledge to construct meaning.

The general public view of science is that it encompasses a cumulative body of specific knowledge assembled by specialist observers using specialized techniques and equipment. These views often confuse quantity with quality of knowledge and are dysfunctional to today's rapidly changing science, technology and society. It is therefore different from constructivist conception of science. A constructivist view of science emphasizes the craft and community aspects of science. Such a view encourages invention since it would unearth the sources of scientific knowledge in continuing human interpretations and reinterpretation of natural and social phenomena (Cornbleth, 1983; Pfundt & Duit, 1994). The following could be attributed to a
constructivist conception of science and science knowledge. We can conceive of science as tentative, integrative, humanly created, social and crafted. Thus, science is:-

1. tentative - it is subject to change in response to new information and more productive theory. It is also dynamic due to the interrelatedness and fluidity of process and substance,

2. Integrative and interpretive of observation and experience in order to explain them and to generate further knowledge.

3. Humanly created and thus, it is subject to reconstruction,

4. Social or communal in so far as it is created by participant-observer who themselves belong to the scientific community; the latter is immersed in larger cultural contexts which assumes diversity of paradigms and possibly antagonistic normative commitments.

5. Crafted by skillful invention, which assumes the possibility of effective human actions on the world.

Researches, which embrace constructivism in science, have focused on the discrepancies between learner's own intuitive and personally constructed knowledge and, the formal instructional disciplined science knowledge of schools and scientists. While individually constructed knowledge is tentative, personal and idiosyncratic, school science is well developed, of high status, highly structured and could be characterized in terms of authority (Watts & Bentley, 1987). Thus, the notion that knowledge is developed can be rightly said to be the central theme of constructivism.

Several research reports in science education at both elementary and secondary school levels have strengthened the viability and reality of the constructivist view of learning in science. For instance, recent research findings continue to corroborate the fact that the individual's construction of meaning is an active process of hypothesizing and hypothesis testing with the resultant effect that the individual learner is responsible for his own learning (Osborne & Freyberg, 1985; Driver, 1986b; Tobin, 1990; Olorundare, 1990; Hawkins, 1994; Duit, 1995). This is what is motivating many science education researchers to seek to redefine the role of the classroom teacher in science teaching and the need to deliberately allow the learner to be actively involved in the teaching-learning processes (Osborne, 1996).

A recent investigation was conducted to determine the nature of constructivism in primary school children's learning and the extent to which primary school science teachers share the constructivist view learning in science. Six primary schools were randomly selected from two Local Government Areas of Kwara State; class six was used in each of the schools. In each school, two science teachers were purposively selected for the study: the most experienced science teacher who usually serves as the head of science and, the science teacher who had the least years of science teaching experience in the school. Their science lessons were observed by the researcher as they treated the same topic of "Energy". Interviews were conducted with these teachers after each lesson. Six students in each class observed were randomly selected and personally interviewed.

Teacher's teaching sessions and responses to interview questions show that ten out of the twelve teachers (83%) were aware that their pupils had (in their own words) 'stubborn' ideas about the topic of energy that was being treated. May of the children were found to harbor views contrary to teacher's scientifically intended views. None of these teachers however knew what to do except to threaten their pupils with phrases such as "... you better absorb this, believe it, you will know it later..." or "you better take it from me, otherwise you will fail the examinations...". The other two teachers were unbothered about their children's prior ideas about energy. When asked why they did so, one of them responded that her main business was to help them and cover the
syllabus so that they would pass the forthcoming examination. She felt that it would be time wasting to begin to take into account their 'local' or 'primitive' views. In each of the six schools, not less than four students of the six selected (67%) complained of their teacher's insensitivity to their difficulties in learning the topic. One 11 year old boy complained about his teacher that "... the man (the teacher) just comes and write it on the blackboard... no, he doesn't want to know what we feel about the topic.... is it fair?....I" This pupil's teacher was later confronted with the preceding statement and he responded that "... they don't know anything. I am just helping them; they just have to learn this topic.... its good for them..."

Generally, it was found from the interviews conducted and observation made in the classroom that, the pupils come to the class with differing views of the topic to be treated and, the teachers did not generally care about those views. Oftentimes, the children did not understand why their views were not given due consideration. The teachers themselves were helpless, as they did not know how to confront students' prior-knowledge. They were also constrained by problems of time and children's everyday language. Teachers tried to 'rush' their pupils through the topic so as to prepare them for the secondary school entrance examinations. Their inability to confront realities of classroom learning resulted in the children having difficulties in assimilating (absorbing) the science knowledge they were expected to. It was found that this created a mismatch between the conceptual task teachers presented and the pupils' conceptualizing abilities. Both teachers and pupils perceived the content tasks differently!

Studies reported in literature show a wide range of intervention activities that could be undertaken to facilitate a more effective children's learning of science. Such could include exposing pre-service science teachers to epistemology foundations of constructivism; are focusing from the nature of curriculum planning, which, at present, is overladden with objectives. As Driver (1986b) observed, it is not possible for developers of curriculum to ascertain "... in a predetermined way what understandings individuals will construct from experience given..." (pg.19). In evaluating children's understanding and achievement therefore, it is necessary to pay attention to both 'correct' and 'incorrect' answers. The latter have been found to open up a lot of insight into the nature of children's thinking processes and the individual and environmental factors that inhibit learning.

Evaluation should not only be a focus on learner's achievement of specified endpoint, it should also be a process of tackling specific issues inhibiting learning. Other intervention strategies could include: encouraging learners to make explicit their own ideas, events and classroom activities that challenge these ideas; encouraging learners to hypothesize and create alternative interpretations of the received science knowledge. Learners would also have to be provided with ample opportunities whereby they could utilize their ideas and determine how they come to terms with phenomena presented. As individuals, children inevitably construct their own purpose for a lesson; they form their own idiosyncratic intentions regarding the activities they'll undertake and subsequently draw their own conclusions for further use. There is therefore a major difference between teachers (curricular) intentions and learning that actually takes place. Consequently, teachers intentions cannot be transferred directly into pupils intentions. The difference between the learners and what was given to them to learn can be due to differences between the ideas they brought to the class and ideas which teachers themselves assumed the children would have brought to the classroom situation (Wittrock, 1974; Olorundare, 1990); Okebukola, 1994.

Implications of Constructivism for Science Teaching and Learning

In our traditional views of learning, the learner is seen as a passive individual whose major role is to assimilate information 'dashed' or 'poured' out by the 'all knowing' classroom
teacher. He is expected to exhibit behaviours that align with the intended outcomes. Furthermore, the curriculum becomes the dominant figure since the teacher's role becomes one of providing relevant training, experiences and environment for the learner to develop his understanding. Using what is available and the prior ideas already in his possession, the learner actually constructs his knowledge and meanings of the learning situation.

One important role of the classroom teacher therefore, is to facilitate the learning of the learner and this can be achieved if the teacher takes into account what the learner knows at any given time. What each learner knows will, as has been stated elsewhere in this paper, depend, on what she/he knows already. Teachers would need to be encouraged to provide learning environments that would facilitate each learner's work using what he knows already to solve puzzles. In doing die latter, the learner constructs fresh insights into the process of learning. This does not prevent learning- from being deliberate and purposeful since relevant learning environment can be provided using well defined and negotiated goals (Tobin, 1990; Tasker, i992). On a general note, primary and secondary school teachers do hold constructivist views of learning. Asking them to embrace this view may be tantamount to asking them to change their views about learning and their classroom practices. Therefore, in teacher development, it becomes clear that teachers' change to new ideas and alternate ways of doing things will depend upon their existing beliefs and practices about the teaching learning process.

Teachers' responsibilities within this perspective would involve taking into account (and thus acting accordingly), children's prior knowledge/ideas and understanding the nature of the concepts to be learned, and the learning outcomes expected, conceptual demands made on the child and the strategies available to the teacher (Scott, Asoko & Driver, 1992). There is no doubt that, the examination - oriented system of education in this country would serve as a major inhibiting factor to a realization of the constructivist ideals of learning. In an attempt to 'cover' the various science syllabi, classroom teachers do not often pay attention to this newly developing but widespread view of learning. The present time constraints' characterizing our schools works is a major threat to the operations of constructivism in our science classrooms.

In the investigation earlier reported in this paper, there was observed several mismatches between educational objectives as officially represented in the syllabus and the actual learning outcomes. This presupposes that, those who organize, develop and implement the science curriculum need to have knowledge of both the subject matter and the ways that learning actually takes place. In this way, the curriculum then becomes a dynamic subject for inquiry. Since what learners take away from lesson experiences are influenced by the way teachers conduct their work, it is necessary for classroom teachers to be encouraged to provide learners opportunities to utilize their prior ideas in making sense of course objectives targets. The teachers should 'arm' himself with relevant background knowledge and ah awareness of children's prior knowledge. He should then ensure that he makes provision for specifically designed and delineated goals and procedures,' which, the learner will take to -achieve them, in addition to these, it is expected that the classroom teacher embark on the use of teaching methods, strategies or techniques that would assist the learner to develop his prior ideas and accommodate them into new ones. Such activities would lead to the provision of a classroom environment in which the learner will be actively involved in discussing assessing and testing new ideas to be learned.

Differences do exist between teachers' curricular intentions and learning that actually take place in children. This is further compounded by the reality of the fact that there are differences between children's prior knowledge that is brought into the lesson and what the classroom teacher expected them to bring to the lesson. This disparity creates other mismatches which include a difference between:- the scientific problem presented to the learner and, what the student eventually took to be the problem; classroom activities proposed by the teacher and
those embarked upon by the learner (irrespective of the effort of the teacher to intervene) and, a difference between the conclusion made by the learner and those expected or intended by the classroom teacher. Children often bring into the teaching/learning situation pre-existing ideas or knowledge, which they need to resolve with incoming science. More often than not, the latter is different from the former and consequently, learners often construct their own meaning for the world and the views of the world. It has been shown that such views are usually tenacious even though teachers do not often recognize them. They nonetheless greatly influence what the learner can (and will) learn/ (Osborne, & Freyberg, 1985).

Conclusion

It is unfortunate that due to the classroom teachers' relative 'unconcerned' or ignorant attitude towards children's pre-existing knowledge and the constructivist perspective of learning, the teacher's work is often planned and executed without taking cognizance of how children learn. How learners think and learn is dominated by what they already know. There's therefore a need for teachers to re-orientate their perceptions about how children learn, i.e. learners generally construct meaning from what they see, hear and experience by utilizing construct mechanisms through their prior ideas/knowledge. Research findings have shown that while teachers make elaborate plans to teach science lessons, the teachers do not often see the importance of such activities. As a result, learners have little or no appreciation of intended outcomes. Relevance of several activities are differently for both learners and teachers! Experiences which children have directly with the physical world, coupled with their informal social interaction within and outside the classroom are the sources of children's individual personal constructs and meanings. It is possible therefore for two learners to create different meanings out of a teacher's classroom presentation. In order to teach effectively and for learners to achieve intended learning outcomes, classroom teachers would need to acknowledge and build on these prior-conceptions and their resulting individual learner's constructs.

References


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