Constructivism as a Referent for Science Teaching

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Introduction

Why is it, in educational settings, we rarely talk about how students learn? Why aren't teachers using how students learn as a guide to their teaching practices? These questions seem almost too absurd to ask; but think, when was the last time you spoke to colleagues about how students learn? Do you observe learning in your classroom? What does it look like? These are a few of the questions that we have begun to ask ourselves and our teaching colleagues.

One way to make sense of how students learn is through constructivism. Constructivism is a word used frequently by science educators lately. It is used increasingly as a theoretical rationale for research and teaching. Many current reform efforts also are associated with the notion of constructivism. But what exactly is constructivism and how can it be useful to the practicing teacher?

Constructivism is an epistemology, a theory of knowledge used to explain how we know what we know. We believe that a constructivist epistemology is useful to teachers if used as a referent; that is, as a way to make sense of what they see, think, and do. Our research indicates that teacher's beliefs about how people learn (their personal epistemology), whether verbalized or not, often help them make sense of, and guide, their practice.

The epistemology that is dominant in most educational settings today is similar to objectivism. That is to say, most researchers view knowledge as existing outside the bodies of cognizing beings, as beings separate from knowing and knowers. Knowledge is "out there," residing in books, independent of a thinking being. Science is then conceptualized as a search for truths, a means of discovering theories, laws, and principles associated with reality. Objectivity is a major component of the search for truths which underlie reality; learners are encouraged to view objects, events, and phenomenon with an objective mind, which is assumed to be separate from cognitive processes such as imagination, intuition, feelings, values, and beliefs (Johnson, 1987). As a result, teachers implement a curriculum to ensure that students cover relevant science content and have opportunities to learn truths which usually are documented in bulging textbooks. The constructivist epistemology asserts that the only tools available to a knower are the senses. It is only through seeing, hearing, touching, smelling, and tasting that an individual interacts with the environment. With these messages from the senses the individual builds a picture of the world.

Therefore, constructivism asserts that knowledge resides in individuals; that knowledge cannot be transferred intact from the head of a teacher to the heads of students. The student tries to make

sense of what is taught by trying to fit it with his/her experience.

Consequently, words are not containers whose meanings are in the words itself, they are based on the constructions of individuals. We can communicate because individual's meanings of words only have to be compatible with the meanings given by others. If a situation occurred in which your meaning of a word no longer sufficed, you could change the meaning of the word. Using constructivism as a referent, teachers often use problem-solving as a learning strategy; where learning is defined as adaptations made to fit the world they experience. That is, to learn, a person's existing conceptions of the world must be unreliable, inviable. When one's conceptions of the world are inviable one tries to make sense out of the situation based on what is already known (i.e. Prior knowledge is used to make sense of data perceived by the senses). Other persons are part of our experiential world, thus, others are important for meaning making.

"Others" are so important for constructivists that cooperative learning is a primary teaching strategy. A cooperative learning strategy allows individuals to test the fit of their experiential world with a community of others. Others help to constrain our thinking. The interactions with others cause perturbations, and by resolving the perturbations individuals make adaptations to fit their new experiential world.

Experience involves an interaction of an individual with events, objects, or phenomenon in the universe; an interaction of the senses with things, a personal construction which fits some of the external reality but does not provide a match. The senses are not conduits to the external world through which truths are conducted into the body. Objectivity is not possible for thinking beings. Accordingly, knowledge is a construction of how the world works, one that is viable in the sense that it allows an individual to pursue particular goals.

Thus, from a constructivist perspective, science is not the search for truth. It is a process that assists us to make sense of our world. Using a constructivist perspective, teaching science becomes more like the science that scientists do it is an active, social process of making sense of experiences, as opposed to what we now call "school science." Indeed, actively engaging students in science (we have all heard the call for "hands-on, minds-on science") is the goal of most science education reform. It is an admirable goal, and using constructivism as a referent can possibly assist in reaching that goal.

Driver (1989) has used a constructivist epistemology as a referent in her research on children's conceptions of science. Children's prior knowledge of phenomena from a scientific point of view differs from the interpretation children construct; children construct meanings that fit their experience and expectations. This can lead children to oftentimes construct meanings different from what was intended by a teacher. Teachers that make sense of teaching from an objectivist perspective fail to recognize that students solve this cognitive conflict by separating school science from their own life experiences. In other words, students distinguish between scientific explanations and their "real world" explanations (the often cited example-that forces are needed to keep a ball in motion versus Newton's explanation is one such example). Children's conceptions are their constructions of reality, ones that are viable in the sense that they allow a child to make sense of his/her environment. By using a constructivist epistemology as a referent teachers can become more sensitive to children's prior knowledge and the processes by which

they make sense of phenomena.

The teaching practices of two teachers at City Middle School may best illustrate how practice can be influenced by making sense of teaching and learning from constructivist-and objectivist-oriented perspective. To Bob, science was a body of knowledge to be learned. His job was to "give out" what he (and the textbook) knew about science to his students. Thus the learning environment Bob tried to maintain in his classroom facilitated this transfer of knowledge; the desks were neatly in rows facing Bob and the blackboard. Lectures and assignments from the text were given to students. Bob tried to keep students quiet and working all during the class period to ensure that all students could "absorb" the science knowledge efficiently. Another consequence of Bob's notion of teaching and learning was his belief that he had so much cover that he had no time for laboratory activities.

Let's look at an example that typifies Bob's teaching style. Bob's sixth grade students were to complete a worksheet that "covered" the concept of friction. After the students completed the worksheet, Bob went over the answers so the students could have the correct answers for the test later in the week. From a constructivist perspective, what opportunities did Bob's students have to relate the concept of friction to their own experiences? Were these opportunities in Bob's lesson plan to negotiate meanings and build a consensus of understanding? Bob spent one class period covering the concept of friction; is that sufficient time for students to learn a concept with understanding?

On the other hand, John made sense of teaching and learning from a constructivist perspective. John's classes were student-centered and activity-based. Typically in his high school classes, John introduced students to different science topics with short lectures, textbook readings, and confirmatory laboratories. After the introduction John would ask students what interested them about the topic and encouraged them to pursue and test these ideas. Students usually divided themselves into groups and then, conducted a library research, formulated questions/problems, and procedures to test the questions/problems. In other words, the students were acting as scientists in the classroom. Like Bob, John taught a sixth grade class previously, and also taught students about friction. Included in John's lessons were activities to "get the students involved." Students rubbed their hands together with and without a lubricant so that they could see the purpose of motor oil in engines. The students conducted experiments with bricks to learn about different types of friction, and even watched The Flintstones in class to point out friction and what would really happen (i.e. Fed would burn his feet stopping the car, etc.) John spent two weeks teaching his unit on friction. Were John's students given opportunities to make sense of the concept of friction? Were they able to use personal experiences? Whose students do you think had a deeper understanding of friction?

Our research also indicates that as teachers made transitions from objectivist to constructivist oriented thoughts and behaviors their classroom practices changed radically (Lorsbach, Tobin, Briscoe, & LaMaster, 1992; Tobin, 1990). It seemed as if many traditional practices no longer made sense to teachers. Specifically, teachers recognized that learning and making sense of what happens rests ultimately with the individual learners. Learners need time to experience, reflect on their experiences in relation to what they already know, and resolve any problems that arise. Accordingly, learners need time to clarify, elaborate, describe, compare, negotiate, and reach

consensus on what specific experiences mean to them. This learning process must occur within the bodies of individuals, however, the inner voices of persons can be supplemented by discussion with others.

Therefore, an important part of a constructivist-oriented curriculum should be the negotiation of meaning. Students need to be given opportunities to make sense of what is learned by negotiating meaning; comparing what is known to new experiences, and resolving discrepancies between what is known to new experiences, and resolving discrepancies between what is known and what seems to be implied by new experience. The resolution of discrepancies enables an individual to reach an equilibrium in the sense that there should be no remaining curiosity regarding an experience in relation to what is known. Negotiation also can occur between individuals in a classroom. The process involves discussion and attentive listening, making sense of the points of views of theories of peers. When a person understands how a peer is making sense of a point of view, it is then possible to discuss similarities and differences between the theories of peers within a group. Justifying one position over another and selecting those theories that are viable can lead to consensuses that are understood by those within a peer group.

The process of learning should not stop at what has been learned in the negotiation of a class consensus. This process can involve accessing other learning resources such as books, videotapes, and practicing scientists. The consensus negotiated within a class can be adapted by students as they make sense of the theories negotiated in other communities. By engaging in such a process students can realize that what is regarded as a viable theory depends on what is known at the time and the context in which the theory is to be applied. Also they can begin to understand how to select the best theoretical formulation for use in a particular set of circumstances.

For many years the conventional wisdom of teachers has been similar to Bob's teaching style: to control student behavior so that the class is quiet. Indeed research programs have been premised on this assumption. Accordingly, the research literature provides lists of teacher behavior and strategies that have been demonstrated to control students. If this assumption is abandoned there is little research to guide teachers in the selection of practices that are conducive to students constructing knowledge. Instead of managing to keep students quiet and attentive to the teacher, a classroom might be managed to enable students to talk with one another and utilize collaborative learning strategies. Instead of keeping students seated in rows throughout a lesson, a management system might be developed which permits students to move about the classroom and visit the library, or a field work station. Management is still a priority, but it is subsumed below learning and the implementation of a curriculum that meets the needs of students.

Establishing and maintaining a learning environment that is conducive to learning is a priority for science teachers. However, this is not easy to do. To begin with, traditional teaching practices are sometimes difficult to discard. Teachers might commence a lesson with good intentions only to find that they forget to follow their game plan. We have learned from our research that sustained change can take a long time to establish. John, a third year teacher, is committed to get all of his students to accept his style of teaching. Many of his students have an image of teaching of which John's style does not fit. Therefore, students might also have difficulty adapting to an environment in which they are given the responsibility for making sense of science. They too

have experienced traditional practices in which they are force fed a diet of factual information to be rote learned. Many students expect to be controlled and filled up with knowledge. They believe teachers to be the experts whose role is to transfer the knowledge to students, much like one fills a bottle with liquid. If teachers do not fulfill their traditional roles students might be confused and have difficulty engaging as intended by the teacher. Just as teachers have to learn how to teach from a constructivist point of view, so too must students learn how to learn. Educating students to be effective learners is an important priority in establishing environments conducive to effective learning of science.

Reflect on your science teaching. Have you provided students with new knowledge to be memorized and repeated on a test without providing an opportunity for them to make sense of it? Or, have you provided students with an opportunity to use their prior knowledge and senses in making connections to the new concepts you introduced? If, like so many traditional science classrooms, the practices in your classroom are based on objectivism, you might like to commence the challenge of implementing change that accord with constructivism. If you would like to change your teaching practices (to whatever degree), then perhaps by reflecting on your practice from a constructivist point of view you can begin to construct a new vision of your classroom.

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