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Constructivism

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Constructivism is a concept that in recent years has garnered considerable attention among science education researchers. Essentially, constructivism is a model of how learning takes place. Yager (1991, p. 53) called it a "most promising model" of learning. Yeany (1991, p. 1) alluded to a Kuhnian paradigm shift and suggested that constructivism may lead "to a gelling of existing thought as well as the stimulation of new ideas." We do not believe this is hyperbole. In fact, we would add that the potential extends far beyond the bounds of science education (see e.g., Aderman & Russell, 1990). It seems to us that constructivist thought is applicable in any learning situation, including educational and psychological consultation. In this column, we first briefly describe constructivist thought as it has developed in the field of science education. Second, we suggest that constructivism can provide a promising conceptual framework for organizing research and practice in the various fields in which consultation is practiced.

Piagetian theory precipitated enormous amounts of educational research, but an inability to translate research findings into practice has been a chronic weakness of Piagetian theory (Novak, 1982). Quite to the contrary, constructivist theory lends itself readily to practical application; and for this reason constructivism is rapidly replacing Piagetian

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theory as the foundation for science education research. Moreover, one of the attractions of constructivism is its utter simplicity. On reflection one would almost say the notion is patently self-evident. However, the widespread adoption of the term constructivism in various areas of education has actually created considerable confusion and controversy. For all its simplicity, the term seems to mean different things to different people. Many have taken a rather pragmatic approach to constructivism. For them, constructivism is simply a description of learning that can be turned about and used to guide teaching, for example, models of conceptual change (e.g., Driver, 1989; Osborne & Wittrock, 1983). Ernst von Glasersfeld (1989) represents those who stand in the opposite corner. For this group, constructivism is essentially an epistemological commitment to instrumentalism grounded in philosophical idealism. He and other radical constructivists argue that it is fundamental that "cognition is adaptive and serves the organization of the experiential world, not the discovery of ontological reality" (Wheatley, 1991, p. 10; also see Tobin, 1991). So what is constructivism? In an effort to foster an intuitive grasp of this concept, we prefer not to start with a definition. Rather, what follows is a descriptive narrative. We trust that the narrative, in somewhat inductive fashion, will evoke in the reader an understanding of constructivism prior to hearing a formal definition.

We all wish to know about the world around us, whether we are speaking of the world in physical, social, or even spiritual terms. In science, one uses the senses of sight, hearing, touch, and taste to learn about physical phenomena. Instruments are used to extend the range of the basic human senses. These instruments can be as simple as an ordinary ruler or as complex as a radio telescope or mass spectrometer. Typically what we have thought in science is that our senses provide authentic data about the real world. Experimentation keeps subjectivity in check. But is that really how our senses work? Consider that science uses the senses to focus only on what can be measured. For example, a scientist typically is not nearly as interested in the color of an object as he or she is in measurable electromagnetic wavelengths emitted or reflected by the object. If you want to build a color television, knowledge of electromagnetic wavelengths is necessary. However, who can say that a wavelength of 4.0×10^{-7} m tells us any more about the reality of an object than does blueness? In fact, philosophers of science tell us that the question cannot be answered. Scientists focus on measurable attributes simply because they have chosen to do so—it works for what they want to do.

There is another question that confronts our attempts to understand reality, regardless of the physical attributes on which one chooses to focus. How do we know that what we perceive is what is actually there?

As early as 1604, Kepler demonstrated that the physical image on the retina of the eye is actually inverted. Yet that is not how we perceive objects. We perceive them right side up. In other words, even though we see an object upside down, we nevertheless perceive it right side up. So how can we say that what we see is actually what is there? Perception appears to involve interpretation rather than simple transmission. To further illustrate the difference between sight and perception, try to image a person born without functioning sense organs. Somehow the person survives and one day after many years, the person's eyes suddenly start functioning. The person's eyes would see reflected light just as ours do; but, what would he or she perceive? A mass confusion of light, a jumble of hues and intensities, a tumult of sensation, all signifying absolutely nothing. The person would not recognize a tree in front of him or her because he or she could not have had any prior knowledge of the concept of tree. Perception is the act of one who sees, not the passive reception of light reflected by objects. To make this more personal, imagine that you have just removed the cover of your personal computer. Few of us know anything at all about the physical apparatus within a computer casing. Open one up and what we perceive is a confusion of lines, shapes, and colors which signify nothing. On the other hand, the computer scientist perceives a computer. This illustrates what the modern developments in the philosophy of science have clearly shown—all observation is theory laden.

There are then two profound limitations on scientific knowledge: First, science is limited by its focus on selected attributes to the exclusion of others. This is a choice made by scientists not a limitation imposed on science by physical reality. Second, one can perceive an object only when one has preexisting knowledge of what is being examined. The result is that the scientist cannot say that he or she has exact knowledge of what reality is like. Rather, the scientist drawing on previous knowledge interprets experience following rules agreed on by the community of scientists. A scientist constructs knowledge to fit experience. Instead of a photograph of reality, scientific knowledge is much more like an artist's impressionistic painting of reality.

This essentially means that scientific knowledge is fallible, and this has implications for teaching as well as consulting. If there were a direct link between the scientist and a physical reality independent of the scientist, one could argue for a direct link between scientific knowledge independent of any knower and the acquisition of scientific knowledge by a learner. This is the viewpoint of naive objectivism. It implies that knowledge can have an existence independent of a knower. It implies that the best way to teach is by careful, methodical, detailed explication of scientific knowledge with the expectation that students will learn by receiving (i.e., memorizing) the knowledge. In fact, that is exactly how science has been taught for many years under the influence of positivism. Positivistic philosophy taught that rationality and objectivity resided in quantitative, experimental science. However, if scientific knowledge is a scientist's meaningful construction based on his or her experiences of reality, how can the learning of scientific knowledge be any different? If I cannot know reality for sure, what is it that I am learning when I learn? Essentially, there is no difference between the original derivation of scientific knowledge by a scientist and the learning of scientific knowledge by a student. Both are acts of interpretation. When I learn a science concept, I am constructing a personal understanding of the concept based on what I perceive the textbook, activity, or teacher to be saying. Just as a scientist interprets experience in light of a personal background of knowledge, I learn by interpretation in light of my personal background of knowledge. In contrast, rote memorization involves no interpretation and is rarely meaningful; and therefore, most of what students memorize is soon forgotten.

The concepts of construction and meaningful learning help make sense of a widespread occurrence among people. Science education research has shown that many people hold many different ideas about such things as motion, force, life, and gravity (Helm & Novak, 1983; Novak, 1987). People's ideas frequently differ considerably from accepted scientific viewpoints, even when the people are students of science. After very careful explication of a concept, students will frequently come away with quite different interpretations of the concept. Even graduate level physics students have been shown to have views of the concept *impetus* that vary considerably from what is consider the scientifically orthodox view (Clement, 1982). This phenomenon prompted Hawkins (1978) to write,

> reasonably patient explanation is no cure . . . we are up against something rather deep in the relation between science and common sense; we are up against a *barrier* to teaching in the *didactic* mode which has hardly been recognized, or if recognized has been seen mainly as a challenge to ingenuity in teaching rather that as a challenge to a deeper understanding of human learning. (pp. 5 & 7, italics added)

What is the barrier? You ask, how do these scientifically unorthodox ideas happen? They happen because learning does not involve photography, but impressionistic artistry. As the learning theorist David Ausubel says, the only real learning is meaningful learning. We have learned something when it makes sense to us. The advanced physics students have a particular impression of what impetus means because that impression makes sense to them. If their impression of impetus does not resemble the teacher's, it is because their impression is a personal construction. If learning occurred by transmission students would either have the concept or not. What they would not have are idiosyncratic versions of the concept.

The definition of constructivism is carried in its name. Learning is the active process of constructing a conceptual framework. The philosophical basis for constructivism is epistemological fallibalism. All knowledge is fallible by virtue of lacking exactitude and comprehensiveness. Ultimately, we can never know for sure how close our knowledge actually approximates reality. Rather, knowledge is a meaningful interpretation of our experiences of reality. If the original derivation of knowledge is by meaningful interpretation, then the learning of knowledge must also involve meaningful interpretation. Thus, no one learns by transmission. No one learns in a way analogous to the copying of a computer file from floppy disk to hard drive. We learn by making sense of what is experienced.

As we mentioned at the start, constructivism is a practical idea. Consider the following:

Teacher: I say to you the man is tall.
Student: I hear you say that the man is tall. I think this man is also tall.
Teacher: No, that man is only 6 ft tall.
Student: Okay, I hear you saying that the first man is tall because he is over 6 ft 4 in.
Teacher: Yes, but you are saying the second man is tall because he is over 6 ft.

We might call this dialogue "coming to an understanding" or "clearing the air," or "seeing eye to eye." The dialogue demonstrates three things. It first demonstrates that both the teacher and the student are learners. Second, the learning was an interpretive process. The student had to interpret the meaning of "tall." The teacher had to interpret the student's response. Third, in order to help the student understand the teacher's intention, the teacher had to come to an understanding of the student's viewpoint (i.e., that student interpreted tall to mean over 6 ft). This, essentially, is the constructivist model of learning. It says to us that learning is always influenced by prior knowledge; therefore, it is crucial that the teacher come to a common understanding with the student. It says to us that learning involves negotiation and interpretation. Therefore, the teacher is advised to engage students in discourse that facilitates the actions of negotiation and interpretation. The discourse may be with the teacher or other students. In this regard, cooperative learning strategies are ideal. Constructivism also implies that activity, or hands-on learning, by itself is not enough. A good inquiry lesson will fail with many students if students are not allowed to engage in negotiation and interpretation of ideas.

There is a further issue to consider. Most people have had the experience of being in a conversation where one would swear that the other person was speaking in an unknown foreign language even though that was not the case. One simply could not make oneself understood by the other person. This failure to communicate happens when the parties bring to the conversation radically different conceptual frameworks. This is not uncommon in the science classroom. The student has no idea what the teacher is talking about. The issue here is contextual constructivism (Cobern, in press). One of the clearest examples of this in science is the topic of origins. The scientific view of origins has to do with evolutionary mechanisms that speak to the question of how. For many students, however, origins is not about how but about why, thus becoming a religious topic rather than a science topic; these students construct knowledge appropriate to the context that is meaningful to them. The result can be a radical schism between teacher and student, which is made only worse when the teacher assails the student's position without ever trying to understand the student.

In summary, constructivism is a model intended to describe learning. The model implies that a student is always an active agent in the process of meaningful learning. Learning does not occur by transmission but by interpretation. Interpretation is always influenced by prior knowledge. Interpretation is facilitated by discourse. Inquiry activities are powerful specifically when they promote discourse. By the same reasoning, science learning through cookbook labs and demonstrations is far less effective. Science educators are coming to see the importance of discourse. Thus one can say, if students are not talking science, the teacher will find that many are not learning science. As to the different views of constructivism, Driver (1989) was content to use the model as a basis for developing teaching strategies. However, von Glasersfeld (1989) was right. There are at work here key issues of epistemology and ontology. The model can be used pragmatically, but we do not think that its full potential can be realized without the support of a philosophical framework.

The challenge is to consider to what extent these notions can inform the field of educational and psychological consultation. Because the field itself has been constructed from a wide variety of disciplines including psychology, sociology, and organizational development, the notion of constructivism may be quite relevant. In particular, collaborative consultation seems to heed the personal ideas that people bring to the consultation process and the importance of talking through ideas for the sake of clarification. In keeping with the search for new paradigms for collaborative consultation (e.g., Villa, Thousand, Paolucci-Whitcomb, & Nevin, 1990) as well as new applications of research methodologies to understand and improve consultation practices (e.g., Pryzwansky & Noblit, 1990), constructivism may offer a conceptual framework that provides the warrant beyond intuition for these practices, as well as providing a framework that can suggest further avenues of research. Some issues that might be worthy of exploration include: How can the concept of "differing world views" facilitate communication between consultants and consultees? How does the consultation process facilitate changes in world views of respective consultants and consultees? How are "deep concept barriers" overcome as a result of the collaborative interactions that take place during consultation? How might constructivism help consultants change their own as well as their consultees' misconceptions and/or already constructed knowledge bases in favor of more useful or more meaningful concepts?

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