Cooperating with Constructivism

Getting the Word Out on the Meaning of “Constructivism”

David T. Crowther

There seems to be some tension building in education and arts and science departments over the issue of constructivism. It seems that articles and discussions nationwide are criticizing "new" teaching methodologies and are blindly racing into arguments advocating "back to basics" with disregard to research on "new" teaching methodologies. For the most recent discussion in mathematics, see February 1999 Phi Delta Kappan.

I first became aware of this argument a while back when I purchased a copy of Scientific American while on a business trip. Scientific American provides a nice overview of current issues in the world of science in language that is easy to read, especially on an airplane where your attention is often diverted.

Specifically, the November 1997 issue of Scientific American (http://www.sciam.com/1997issue/1197review1.html) had a very critical review of constructivism and science education that provoked this response. One can directly access the article at (http://www.sciam.com/1197issue/1197review1.html).

In the "Reviews and Commentaries" section, Douglas R. O. Morrison critiques Alan Cromer’s new book entitled Connected Knowledge: Science, Philosophy, and Education (1997). Morrison begins by saying:

I began to wonder some years ago why my children were learning science in such a crazy fashion. Teachers told them to do lab experiments but gave them no textbooks or notes to explain why they were doing those experiments or what they meant—evidently, the students were supposed to work it all out for themselves. At a P.T.A. meeting, I protested and was told that this was the new fashion in education. None of the other parents, I was informed, had made any complaint, except the ones who were scientists. This circumstance seemed to me to indicate a problem. Most scientists have never heard of the "Science Wars," they are too busy working to worry about how sociologists think their enterprise progresses. But it is becoming increasingly common knowledge that a harmful vision of science has been steadily taking over education in schools and universities (p. 114).

Morrison continued that the problem was in the "new" way of learning and understanding science:

Cromer gradually compars science and its methodology with the ideas of the "postmodernists," who question the objectivity of science and even the existence of objective reality. What I found particularly worrying in this section of the narrative was the author’s description of how postmodernists have applied their ideas to education. In that arena, the movement is called constructivism, derived from the notion that all facts are socially constructed rather than being deduced from evidence. I often hear American scientists lament the low standard of education in their public schools. After reading Cromer’s explanation of how constructivists have worked their ideas into science teaching programs and introduced their nonscientific ideas, I can well understand how these actions have exacerbated the problems (p. 116).

Surprisingly, constructivist roots can be traced to the same town where Mr. Morrison worked for 38 years at the European Laboratory for Particle Physics in Geneva, Switzerland.

I always thought that scientists and science educators (in many cases the same people) should work together, not wage war against one another. After all, science educators are the ones educating scientists’ children.

Without making the "us and them" an issue, science educators need to better inform the general public and scientific communities of what this notion of constructivism is and why this new trend is working its way into schools and universities.

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However, when science educators gather together and the word "constructivism" is used, many people pause and ask for clarification of that person's definition of constructivism. Therefore, I will give my very brief overview of constructivism along with some resources for people to review to come to a better understanding for themselves and to learn the implications that constructivism may have on their own teaching methodology.

CONSTRUCTIVISM DEFINED

Basically defined, constructivism means that as people experience something new, they internalize it through past experiences or knowledge constructs that have been previously established. Resnick (1983) states that "Meaning is constructed by the cognitive apparatus of the learner" (p. 477). Saunders (1992) explains and agrees with Watzlawick (1984) that "Constructivism can be defined as that philosophical position which holds that any so-called reality is, in the most immediate and concrete sense, the mental construction of those who believe they have discovered and investigated it. In other words, what is supposedly found is an invention whose inventor is unaware of his act of invention and who considers it as something that exists independently of him; the invention then becomes the basis of his world view and actions." These past experiences are also referred to as our world view.

Novak and Gowin (1986) further define constructivism as "the notion that humans construct or build meaning into their ideas and experiences as a result of an effort to understand or to make sense of them. This involves at times recognition of new regularities in events or objects, inventing new concepts or extending old concepts, recognition of new relationships (propositions) between concepts, and... making a new framework of conceptual frameworks to see new higher order relationships" (p. 356).

During the years of childhood, children's ideas evolve as a result of experience and socialization into "common sense" views (Driver, Asoko, Leach, Mortimer, and Scott 1994). Steffe (1990) explains, "Constructivists view learning as the adaptations children make in their functioning schemes to neutralize perturbations that arise through interactions with our world."

Fabricius (1983) modifies Piaget's Schema Theory interpreting it to mean that "reality becomes the phenomena we experience through construction." Wheatly (1991) suggests two principles of learning embodied in the constructivist theory:

Principle one states that knowledge is not passively received, but is actively built up by the cognizing subject. Ideas and thoughts cannot be communicated in the sense that meaning is packaged into words and sent to another who unpacks the meaning from the sentences. That is, as much as we would like to, we cannot put ideas in student's heads, they will and must construct their own meanings.... Principle two states that the function of cognition is adaptative and serves the organization of the experiential world, not the ontological reality (as quoted von Glasersfeld 1987). Thus we do not find truth but construct viable explanations of our experiences (1991).

Scott (1987) defines a constructivist in science as one who "perceives students as active learners who come to science lessons already holding ideas about natural phenomena, which they use to make sense of everyday experiences.... Such a process is one in which learners actively make sense of the world by constructing meaning."

Tobin and Tippins (1993) would add to the definition of the construction of knowledge in science education. They state that the constructed knowledge of science is "viewed as a set of socially negotiated understandings of the events and phenomena that comprise the experienced universe" (p. 4). They further explain that in order to have new knowledge, that "knowledge is accepted by the scientific community as viable because of its coherence with other understandings and its fit with experience." An interesting debate stems from this definition of how "new" knowledge then comes about.

Tobin and Tippins (1993) continue to explain that "scientific knowledge
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continues to change over time because goals and problems of society change leading to new experiences; technology provides new ways of experiencing; what is known continues to increase at an exponential rate; and the individuals that comprise the scientific discipline continually change" (p. 4).

HISTORICAL PERSPECTIVE

Although constructivist theory has reached high popularity in recent years, the idea of constructivism is not new. Aspects of the constructivist theory can be found among the works of Socrates, Plato, and Aristotle (ranging from 470-320 B.C.), all of which speak of the formation of knowledge.

Saint Augustine (354-430 A.D.) taught that in the search for truth people must depend upon sensory experience. This of course left him out of balance with the Catholic Church. More recent philosophers such as John Locke (1632-1704) taught that no man’s knowledge can go beyond his experience.

Immanuel Kant (1724-1804) explained that the “logical analysis of actions and objects lead to the growth of knowledge and the view that one’s individual experiences generate new knowledge” (Brooks and Brooks 1993: 23). Although the main philosophy of Constructivism is generally credited to Jean Piaget (1896-1980), Henrič Pestalozzi (1746-1827), also from Switzerland, came to many similar conclusions over a century earlier.

Pestalozzi maintained that the educational process should be based on the natural development of the child and his or her sensory influences. Pestalozzi’s basic pedagogical innovation was his insistence that children learn through the senses rather than with words. He labeled rote learning as mindless, and he emphasized instead linking the curriculum to children’s experiences in their homes and family lives (Ornstein and Hunkins 1993: 75).

However, Piaget is often regarded as the father of constructivism and provided the foundation for modern day constructivism. Berger (1978) notes:

In Piaget’s view, intelligence consists of two interrelated processes, organization and adaptation. People organize their thoughts so that they make sense, separating the more important thoughts from the less important ones as well as connecting one idea to another. At the same time, people adapt their thinking to include new ideas, as new experiences provide additional information. This adaptation occurs in two ways, through assimilation and accommodation. In the former process, new information is simply added to the cognitive organization already there. In the latter, the intellectual organization has to change somewhat to adjust to the new idea (p. 55).

Constructivist theory in education actually is a branch of neo-Piagetian thought that is rooted in Personal Constructivism (Novak 1977; von Glasersfeld 1989). Soloman (1987), Millar (1989), and Cobern (1993) have taken Personal Constructivism and have paved a way for Contextual Constructivism. Contextual Constructivism is defined by how the learner interprets phenomena and internalizes these interpretations in terms of their previous experience and culture. Cobern (1991) explains:

One must not suppose that cultural identification is limited to such conspicuous group identifiers as race, language or ethnicity... each of these no more identifies a homogenous cultural group than does the term American... In addition to race and language, other significant factors influence the construction of meaning and therefore are part of cultural identity. These include economic and education levels, occupation, geographic location, gender, religion, and philosophy. Thus, one can expect to find considerable variation among students. A student constructs knowledge so that the knowledge is meaningful in the student’s life situation.

Constructivism or a constructivist view puts the students, their interests, and previous experiences and knowledge as paramount parts of understanding in designing curriculum. This has a particular impact when exploring the implications of pedagogy and teacher training.

CONSTRUCTIVISM AND ITS IMPACT ON BEST PRACTICES

Von Glassersfeld (1990) said, “Knowledge is not a commodity which can be communicated.” The philosophy of Constructivism has been discussed and debated by researchers such as Von Glassersfeld (1981, 1989, 1990), Tobin (1993) Cobb (1994), and Cobern (1993), but these authors are concerned about constructivism as a philosophy and through debate leave the practitioner in the field confused.

A while back an entire issue of Educational Researcher (October 1994) was devoted to the philosophical debate with little, if any, resolve to the implications on classroom practice. Other authors have explored the impact of constructivism on pedagogy and even have prescribed certain “best practices” that a “constructivist” teacher should exhibit (e.g., Brooks and Brooks 1993; Saunders 1992; Wheatley 1991), only to find themselves under careful scrutiny and condemnation of the philosophical folk who state that a philosophy has no prescribed methods. Specifically, Tobin and Tippins (1993) warn against reducing constructivism to set of methods and that this would “diminish its power as a set of intellectual referents for making decisions in relation to actions” (p. 7).

PRACTICAL APPLICATIONS OF CONSTRUCTIVISM

What is the practitioner to do? What should be taught and modeled to the future teachers in preparation? The purpose of this section is to explore what “best practices” are associated with constructivist teaching.

In 1991, Wheatley proposed a model of constructivist teaching using the problem-centered learning approach. Wheatley (1991) quotes Kozemsky (1980) stating that “each student must be encouraged to build
his/her own conceptual constructs that will permit the ordering of knowledge into useful problem solving schema” (p. 152). Then Wheatley proposed that the teachers role is to “provide stimulating and motivational experiences through negotiation and act as a guide in the building of personalized schema” (p. 14).

Wheatley’s (1991) problem-centered learning approach has three components: tasks, groups, and sharing. The model is a simple one to follow. Wheatley (1991) suggests that “in preparation for a class a teacher selects tasks which have a high probability of being problematical for students—tasks which may cause students to find a problem. Secondly, the students work on these tasks in small groups. During the time the teacher attempts to convey collaborative work as a goal. Finally, the class is convened as a whole for a time of sharing” (p. 15).

Wheatley (1991) then goes in further detail of the selection of tasks being based upon student beliefs and that the tasks should contain the following 10 attributes:

▲ Be accessible to everyone at the start.
▲ Invite students to make decisions.
▲ Encourage “what if” questions.
▲ Encourage students to use their own methods.
▲ Promote discussion and communication.
▲ Be replete with patterns.
▲ Lead somewhere.
▲ Have an element of surprise.
▲ Be enjoyable.
▲ Be extendable.

While the students are working together on the problem, the elements of cooperative learning as outlined by Johnson and Johnson (1987) should be taken into consideration, including positive interdependence, face-to-face interaction, individual accountability, and the appropriate use of interpersonal and small-group skills.

After the children have had an opportunity to explore the problem for about 25 minutes, Wheatley (1991) suggests that the teacher lead the class in a discussion in which each of the groups presents its solution methods, inventions, and insights. It is important for the teacher to maintain a neutral stance during this session and not correct any “wrong” answers, allowing the students instead to discuss them. Sharing of both models and promotes

to others in the classroom. Wheatley’s model is also open to any subject or content desired by the practitioner.

Another approach to pedagogy, but more specifically related to science education is Saunders’ (1992) four-step approach. Saunders (1992) states that being a constructivist in science education does have implications and that the implications lead to a certain approach to teaching science.

His first step is to organize hands-on investigative labs. These are prob-

![Image](https://via.placeholder.com/150)

Prof. Crowther takes an activity students are familiar with, such as bowling, and teaches them the physics behind the activity.

higher-level thinking and reasoning skills and often leads the students to further “conversations” and thinking in their own heads.

Wheatley’s (1991) problem-centered approach to learning is a simple and open-ended approach to learning that many teachers already use or could adapt current curriculum to fit within. The bonus of Wheatley’s model are the metacognitive skills in understanding how one solves problems compared

lem-centered and differ from the traditional “recipe” labs in that there are no prescribed methods or procedures to solving the problem or exploring the phenomena. Saunders (1992) states that in using the inquiry approach, the students must utilize their own schema to formulate expectations about what is likely to be observed.

The second implication is that there is active cognitive involvement. This is in contrast to the passive learning that
takes place in many “teacher-centered” classrooms. Saunders (1992) explains that learning is made meaningful through activities like “thinking out loud, developing alternative explanations, interpreting data, participating in cognitive conflict (constructive arguing about phenomena under study), development of alternative hypotheses, the design of further experiments to test alternative hypotheses, and the selection of plausible hypotheses from among completing explanations” (p. 140).

The third component to Saunders’ (1992) model is that students work in small groups. Saunders (1992) explains that “small-group work tends to stimu-

late a higher level of cognitive activity among larger numbers of students than does listening to lectures and thus provides expanded opportunities for cognitive restructuring.”

The last implication of Saunders’ (1992) model is higher-level assessment. Although vague about what is really meant by this implication, the literature on alternative assessment is vast.

Saunders (1992) explicitly states that by incorporating the above three strategies without assessing the way the component was taught, student cognitive activity will remain at a low level. The assessment tool should fit the task and reflect the way that learning took place in the classroom. Explaining how

the component was taught has significant implications for the traditional fill-in-the- blank and multiple-choice tests.

Saunders (1992) has some great advice and relevance to the person who claims to be a constructivist. Although the strategies fit well within the science classroom, they can be easily adapted to fit any subject area and accommodate many different learning styles.

One of the most reader-friendly works entailing best practices for a constructivist classroom is the book written by Brooks and Brooks (1993), A Case for the Constructivist Classroom, published by ASCD. The authors explain that the “constructivist vista... is... and Brooks (1993) also have a model that is conducive to any teaching environment and subject. The above models are not prescribed tasks, but rather “best practices” that constructivist teachers use. All of the models allow for the individual needs and conditions that the teacher may find himself or herself in and accommodate most subjects taught in the schools.

CONCLUSIONS AND IMPLICATIONS

COSTA AND LIEBMANN (1995) EXPLAIN THAT:

...with knowledge doubling every five years—every 73 days by the year 2020—we can no longer attempt to anticipate future information requirements. If students are to keep pace with the rapid increase of knowl-
edge, we cannot continue to organize cur-
curriculum in discrete compartments... the disci-
pleines as we have known them, no longer exist. They are being replaced by human in-
quiry that draws upon generalized transdisciplinary bodies of knowledge and relationships (p. 23).

All of the above models and authors would agree that in order to claim that one is a constructivist, there are certain philosophical implications to the way one teaches. These philosophical implications do indeed lead to best practices in the constructivist teacher’s classroom regardless of the discipline taught.

Some of the practices that were common among all of the models were a greater understanding of developmental psychology and learning models, group learning using cooperative-learning strategies, active cognitive involvement (hands-on/heads-on), personal input from students regarding relevant information, student-centered—not subject-centered—classroom environments, integration of subject matter to convey connections to the experiential world, interaction, discussion and reflection, and flexibility of teacher in both curriculum and pedagogical strategies.
What is interesting is the lack of behavioral objectives or specific content-related outcomes. This does not mean that the content is not important, but supports the idea advocated by the National Science Education Standards (NRC 1996) that the content must be taught in conjunction with the processes of learning science. The Standards employ science content as only one part of several facets of science instruction. The standards equally encourage the process of doing science along with history, philosophy, technology, connections of unifying themes in science, and a personal and social perspective in science with the three basic content areas of life, physical, and earth science.

Science is a process of understanding and exploring the world in which we live. The Standards advocate that “Learning science is something that students do, not something that is done to them” (p. 20). The Standards also state that “since science content increases and changes, a teacher’s understanding in science must keep pace” (p. 57). They go even further to suggest how teachers and prospective teachers should learn and keep pace with science: “Prospective and practicing teachers must take science courses in which they learn science through inquiry, having the same opportunities as their students will have to develop understanding” (p. 60).

It seems that if we are to address the problem of being able to use knowledge, we must teach our students how to access and use knowledge that is already present, to problem solve, and to teach inquiry skills so that new knowledge can be sought after and obtained.

After all, the cure to cancer will not come from following directions on a recipe lab!

This brings us back to Morrison’s comments in Scientific American. Knowledge is understood by the learner through existing schema, whether the schema is correct or not allowing for accommodation or assimilation of new knowledge. Students will learn in most situations, the goal of both the colleges of arts and sciences and colleges of education should be finding ways to teach science that provide for the best learning for all students.

All of us who have taken a traditional lecture/text course know how long we retained memorized knowledge. Several people have researched this and it is common knowledge that after taking the test almost 50 percent of what was memorized is lost and then over a period of weeks the “forget curve” approaches 90 percent. However, we all know that the information we were really interested in or that we had to explore through investigative means lasts much longer.

This all applies if we are interested in future voters who can spit out unrelated facts to ambiguous or unconnected issues. If we want, however, a “Science Savvy” rather than a “Science Shy” (Port 1993) population, we must provide means of understanding knowledge through more inquiry. By offering experiences that have direct application to the world around the learner, the learner becomes part of the equation in the development and execution of the content explored. After all, I am sure that when Morrison reflects on his definition of science, he will relate his time in the lab discovering new things in physics and comparing them to what other physicists have done in relation to his new discoveries rather than memorizing unrelated facts to other issues.

In conclusion, the main point still remains: the public should be informed and our peers in other disciplines must be better educated in what constructivism is and how using this philosophy and the best instructional practices will help students become better, problem solvers, citizens, and even, perhaps, better scientists.

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