Constructivist Learning and Teaching

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In reality, no one can teach mathematics. Effective teachers are those who can stimulate students to learn mathematics. Educational research offers compelling evidence that students learn mathematics well only when they construct their own mathematical understanding (MSEB and National Research Council 1989, 58).

Radical changes have been advocated in recent reports on mathematics education, such as NCTM's Curriculum and Evaluation Standards for School Mathematics (National Council of Teachers of Mathematics 1989) and Everybody Counts (MSEB and National Research Council 1989). Unfortunately, many educators are focusing on alterations in content rather than the reports' recommendations for fundamental changes in instructional practices. Many of these instructional changes can best be understood from a constructivist perspective. Although references to constructivist approaches are pervasive, practical descriptions of such approaches have not been readily accessible. Therefore, to promote dialogue about instructional change, each "Research into Practice" column this year will illustrate how a constructivist approach to teaching might be taken for a specific topic in mathematics.

What Is Constructivism?

Most traditional mathematics instruction and curricula are based on the transmission, or absorption, view of teaching and learning. In this view, students passively "absorb" mathematical structures invented by others and recorded in texts or known by authoritative adults. Teaching consists of transmitting sets of established facts, skills, and concepts to students.

Constructivism offers a sharp contrast to this view. its basic tenets–which are embraced to a greater or lesser extent by different proponents–are the following:

1. Knowledge is actively created or invented by the child, not passively received from the environment. This idea can be illustrated by the Piagetian position that mathematical ideas are made by children, not found like a pebble or accepted from others like a gift (Sinclair, in Steffe and Cobb 1988). For example, the idea "four" cannot be directly detected by a child's senses. It is a relation that the child superimposes on a set of objects. This relation is constructed by the child by reflecting on actions performed on numerous sets of objects, such as contrasting the counting of sets having four units with the counting of sets having three and five units. Although a teacher may have demonstrated and numerically labeled many sets of objects for the student, the mental entity "four" can be created only by the student's thought. In other words, students do not "discover" the way the world works like Columbus found a new continent. Rather they invent new ways of thinking about the world.

2. Children create new mathematical knowledge by reflecting on their physical and mental actions. Ideas are constructed or made meaningful when children integrate them into their existing structures of knowledge.

3. No one true reality exists, only individual interpretations of the world. Their interpretations are shaped by experience and social interactions. Thus, learning mathematics should be thought of as a process of adapting to and organizing one's quantitative world, not discovering preexisting ideas imposed by others. (This tenet is perhaps the most controversial.)

4. Learning is a social process in which children grow into the intellectual life of those around them (Bruner 1986). Mathematical ideas and truths, both in use and in meaning, are cooperatively established by the members of a culture. Thus, the constructivist classroom is seen as a culture in which students are involved not only in discovery and invention but in a social discourse involving explanation, negotiation, sharing, and evaluation.

5. When a teacher demands that students use set mathematical methods, the sense-making activity of students is seriously curtailed. Students tend to mimic the methods by rote so that they can appear to achieve the teacher's goals. Their beliefs about the nature of mathematics change from viewing mathematics as sense

making to viewing it as learning set procedures that make little sense.

Two Major Goals

Although it has many different interpretations, taking a constructivist perspective appears to imply two major goals for mathematics instruction (Cobb 1988). First ' students should develop mathematical structures that are more complex, abstract, and powerful than the ones they currently possess so that they are increasingly capable of solving a wide variety of meaningful problems.

Second, students should become autonomous and self-motivated in their mathematical activity. Such students believe that mathematics is a way of thinking about problems. They believe that they do not "get" mathematical knowledge from their teacher so much as from their own explorations, thinking, and participation in discussions. They see their responsibility in the mathematics classroom not so much as completing assigned tasks but as making sense of, and communicating about, mathematics. Such independent students have the sense of themselves as controlling and creating mathematics.

Teaching and Learning

Constructivist instruction, on the one hand, gives preeminent value to the development of students' personal mathematical ideas. Traditional instruction, on the other hand, values only established mathematical techniques and concepts. For example, even though many teachers consistently use concrete materials to introduce ideas, they use them only for an introduction; the goal is to get to the abstract, symbolic, established mathematics. Inadvertently, students' intuitive thinking about what is meaningful to them is devalued. They come to feel that their intuitive ideas and methods are not related to real mathematics. In contrast, in constructivist instruction, students are encouraged to use their own methods for solving problems. They are not asked to adopt someone else's thinking but encouraged to refine their own. Although the teacher presents tasks that promote the invention or adoption of more sophisticated techniques, all methods are valued and supported. Through interaction with mathematical tasks and other students, the student's own intuitive mathematical thinking gradually becomes more abstract and powerful.

Because the role of the constructivist teacher is to guide and support students' invention of viable mathematical ideas rather than transmit "correct" adult ways of doing mathematics, some see the constructivist approach as inefficient, free-for-all discovery. In fact, even in its least directive form, the guidance of the teacher is the feature that distinguishes constructivism from unguided discovery. The constructivist teacher, by offering appropriate tasks and opportunities for dialogue, guides the focus of students' attention, thus unobtrusively directing their learning (Bruner 1986).

Constructivist teachers must be able to pose tasks that bring about appropriate conceptual reorganizations in students. This approach requires knowledge of both the normal developmental sequence in which students learn specific mathematical ideas and the current individual structures of students in the class. Such teachers must also be skilled in structuring the intellectual and social climate of the classroom so that students discuss, reflect on, and make sense of these tasks.

An Invitation

Each article in this year's "Research into Practice" column will present specific examples of the constructivist approach in action. Each will describe how students think about particular mathematical ideas and how instructional environments can be structured to cause students to develop more powerful thinking about those ideas. We invite you to consider the approach and how it relates to your teaching-to try it in your classroom. Which tenets of constructivism might you accept? How might your teaching and classroom environment change if you accept that students must construct their own knowledge? Are the implications different for students of different ages? How do you deal with individual differences? Most important, what instructional methods are consistent with a constructivist view of learning?

References

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