The Affective Side of Science Instruction

Reasons for science instruction are usually stated in terms of cognitive objectives: to help children develop the ability to solve problems; to engage in the processes of inquiry, exploration and discovery; to develop skills in observation, verification, hypothesizing and reasoning; and to gain scientific knowledge and information. When we consider Einstein's thoughts on science instruction, however, it is clear that he believed the very foundations of science lie in affect (emotion). He captures a side of science that resides in the affective realm of curiosity and enjoyment. Einstein, the consummate intellectual, admonished educators to promote the affective side of science or else risk strangling the scientific process.

A case for the "affective side of science instruction" begins with our conceptualization of learning. With the advent of Skinner behaviorism, learning theory has been dominated by "what can be observed" in learning. Since emotion is more difficult to observe and document, it has been either ignored or placed on the periphery of the learning process. Piaget (1967), however, wisely pulls human learning into a "whole" construct of both affect and cognition. This is contrary to the traditional paradigm of learning, which focuses primarily on the cognitive side. Piaget, known for his cognitive learning theory, does not promote cognition in absence of affect. Instead, he envisions learning as one interactive process of affect and cognition. Cognition and affect are co-constructed by constant interaction between the two; the two cannot be considered separately in the learning process (Bearison & Zimiles, 1986; Piaget, 1967).

Within this interactive process, emotions direct us to relate to our environment. Zimiles (1981) suggests that the affect system is not merely a necessary condition for learning, an independent driving force, but rather an interactive element that, in addition to setting off the learning process, contributes to its scope and character by steering and monitoring the cognitive performance. (p. 52)

Interest directs and organizes the cognitive activity of assimilation (Langsdorf, Izard, Rayias & Hembree, 1983). Bearison and Zimiles (1986) suggest that "without affect there would be no interest, no need, no motivation; and consequently ... there would be no intelligence" (p. 3). From a Piagetian point of view, the affective side of assimilation is interest, whereas the cognitive side is understanding (Langsdorf et al., 1983; Piaget, 1967).

Carson (1960) notes that "first emotion is aroused; the emotions serve as a catalyst to seek knowledge. Once found, the information has lasting meaning" (p. 45). When, however, "emotions (associated with an event) are muted, memories of the event are less enduring" (Restak, 1979, p. 194). That is, we remember what we understand, and our ability to grasp understanding depends on our motivation and interest.

Harlan (1988) characterizes science as the human desire to understand the world and how it is organized. It is curiosity and the desire to understand that motivate individuals to seek knowledge. Thus, scientific genius does not develop from prescribed lessons with defined objectives; it occurs when curiosity and passion for discovery are cultivated.

Let us consider, for example, the words of Richard Feynman, Nobel Laureate in physics. He combined desire and enjoyment as the motivation for his pursuit of the science of physics:

Why did I enjoy doing it [physics]? I used to play with it. I used to do whatever I felt like doing. It didn't have to do with whether it was important for the development of nuclear physics, but instead whether it was interesting and amusing for me to play with ... I'd invent things and play with things for my own entertainment ... [Once] I was in the cafeteria and some guy, fooling around, throws me a plate in the air. As the plate went up in the air, I saw it wobble, and I noticed the red medallion of Cornell [University] on the plate going around. It was pretty obvious to me that the medallion went around faster than the wobbling.

I had nothing to do, so I started to figure out the motion of the rotating plate. I discovered that when the angle is very slight, the medallion rotates twice as fast as the wobble rate: two to one. It came out as a complicated equation! I don't remember how I did it, but I ultimately worked out what the motion of the mass particles is, and how all the accelerations balance to make it come out two to one. I still remember Hans Bethe saying to me, "Hey, Feynman. That's pretty interesting, but what's the importance of it? Why are you doing it?"

Hah, I say. There's no importance whatsoever. I'm just doing it for the fun of it. His reaction didn't discourage me. I had made up my mind. I was going to enjoy physics and do whatever I liked ... The diagrams and the whole business that I got the Nobel Prize for came from that messing around with the wobbling plate. (Feynman, 1985, p. 173-174)

Feynman's curiosity, desire and enjoyment led him to seek knowledge in the realm of physics (Harlan, 1988). Without affect, Feynman would not have engaged in the scientific process of discovery that ultimately won him the Nobel Prize. This is not an obscure example of one scientist's adventure into new knowledge; rather, Feynman's experience is reflective of the "whole" process of learning, the interaction of affect and cognition.

In addressing methods of science instruction, we must provide for learning experiences that include both affect and cognition. The classroom teacher should consider three critical areas:

* The Affective Environment. Providing an enriched environment that encourages hands-on experiences (i.e., centers, projects) is a necessary component of active, cognitive learning. The knowledgeable teacher, however, must also establish the affective environment, which interacts with cognitive learning.

First, the affective environment must be "risk-free" so that children have the opportunity to explore, experiment and solve problems without the fear of failure. Play creates a natural risk-free environment. Opportunities for free-play with science materials promote a child's curiosity and willingness to consider varying options (Henniger, 1988). Wassermann (1992) notes that In play, there is no fear of failure, because there is no failure. Failure occurs when children have not measured up to another's preconceived notion of what they should have done. No standards of right and wrong are articulated in play, and the absence of such standards is what allows for innovation. (p. 135)

Second, the affective environment is enjoyable. As Feynman noted, he "enjoyed" playing with physics problems. Affective environments that nurture joy allow children to create, invent and pursue solutions.

Third, the affective environment eliminates the stress of time constraints. Children must be able to play freely with science materials, without a strict time frame in which to finish, complete or draw conclusions. The time frame must be adequate so that children feel the freedom to explore different solutions or create multiple scenarios.

Fourth, the affective environment provides choice, which is an expression of the affect interest, and is an integral part of the "desire to know." Children will make their own discoveries during free-play with their chosen science materials and they will construct their own knowledge of a phenomenon. Also, through choice, children feel ownership of the process, rather than feeling coerced or obliged to explore (Einstein, 1954).

* The Affective Teacher. Children are more likely to imitate behaviors and attitudes that they perceive as pleasurable and beneficial. Thus, children's attitudes are greatly shaped by how a teacher engages in the science process. It is the responsibility of the teacher to model the affective realm of curiosity, excitement and enjoyment, as well as a desire to know. Her feelings of wonder and joy will, in turn, generate interest in the scientific process of discovery.

Rivkin (1992) notes that "laughing, squealing, joyously shared science is a goal worth seeking for yourself and for children. People learn best what they enjoy" (p. 4). The affective teacher should also value and support children in their own explorations, demonstrating that she is comfortable with "playing" and "messing around" with scientific materials. If the teacher is overly concerned with following exact procedures, keeping materials clean or orderly, and conducting a quiet classroom, her feelings will impede the process of discovery. Children, who naturally embrace the science adventure, often can be conditioned over time to no longer care, or want to know. The non-affective teacher can strangle the "curiosity of inquiry," the "joy of seeing and searching" (Einstein, 1954).

* The Affective Child. A teacher should understand and support the affect of the child by realizing that "emotions are constantly at work in the functioning of thought" (Izard, 1986). A child's affect will positively or negatively reinforce his desire to know.

First, a teacher should support a child's autonomy. Autonomous children freely explore their interests in self-directed learning, while children who are controlled by adults are less likely to follow through on their curiosity, or to rely on their own problem-solving efforts.

Second, a teacher should understand the role of self-confidence and self-esteem. The self-confident child will pursue a problem, whereas an insecure child will not. A child with low self-confidence may enter into a state of "learned helplessness," thus withdrawing from an experience or problem-solving situation.

Children with positive self-esteem are risk-takers, because they see themselves as competent individuals. They are more apt to explore and engage in problem-solving experiences, are less anxious, concentrate more, spend more time on task because of enjoyment, attend to critical elements of a problem, are more spontaneous and are more apt to pursue and generate multiple solutions to problems (Fenn & Iwanicki, 1986; Flynn, 1984). Science-related self-esteem should result in a child stating, "I am a scientist," rather than "I'm no good at science."

Third, a teacher should promote each child's success. Feelings of success or failure can, respectively, facilitate or inhibit learning (Izard, 1986). Children who expect success will seek out increasingly difficult problems, because children naturally pursue problems they feel they can solve. A child will have greater opportunity for success in free-play exploration and open-ended science activities than when trying to solve an experiment that only has one answer. Anxiety, fear of failure and learned helplessness thrive in a science curriculum that only accepts one right answer, and in which every experiment is devised by the teacher.

To allow a child's affect to interact with cognition, the teacher should provide him with greater freedom to explore, to choose his problems to solve, to try new ways of doing things, to experience success and to have sufficient time to let his mind and emotions enjoy the process of discovery.

In conclusion, teachers must consider the innate passion to discover and the desire to understand when designing science instruction. In an emotionally secure and stimulating environment, children will freely express the passions to discover and understand. We must ensure and support every child's affective development along with his cognitive development. We cannot address the cognitive side of science without wisely promoting the affective side as well. If not, we are making a truly grave mistake (Einstein, 1954). Added material

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