Conceptual Change and the Myth of Restructuring and Replacing Conceptions

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During the past ten years the theoretical and pedagogical framework of conceptual change has developed into one of the major "movements - in science education research and is beginning to influence actual science teaching practice, as well. From the major formulation of "conceptual change" theory in science education (Posner, Strike, Hewson, & Gertzog, 1982), numerous researchers have investigated and elaborated upon this theoretical and pedagogical framework. For the most part, however, very few critical analyses of conceptual change theory have occurred. White and Gunstone (1989), however, express dissatisfaction with the term "conceptual change" and suggest that "principle change" or "belief change" would have described the notion more accurately. The field is moving ahead very quickly, but without the degree of argumentation necessary for sound theoretical development. As a result, the literature contains (a) a wide range of interpretations of what conceptual change means and (b) a number of assumptions that have not been addressed. The present paper will examine how conceptual change is commonly interpreted, how such interpretations conflict with the intent of conceptual change theory, and how the fundamental assumption of such interpretations creates an inadequate guiding metaphor for the implementation of conceptual change instruction.

Conceptual Change Theory

Although conceptual change has been discussed *over* the past several decades, the recent theoretical formulations of Posner et al. (1982) and Carey (1985) have their roots in philosophy of science from Kuhn, Lakatos, and Toulmin and in children's science or psychological constructivism with historical foundations in Ausubel, Piaget, and Kelly. Conceptual change from this perspective involves *conceptions*. Conceptions are viewed as the psychological equivalent of theories in that they are central organizing factors. Strike and Posner (1992) and Carey (1985) consider such conceptions to be few in number. From this point of view, conceptual change is not particularly a common occurrence.

On the other hand, many other researchers view conceptual change as dealing with rather specific concepts (Basili & Sanford, 1991; Brown. 1992; Brown & Clement. 1989, March; Dreyfus, Jungwirth, & Eliovitch, 1990; Dupin & Joshua. 1989; Fazio. 1989; Gunstone, Gray, & Searle, 1992; Kelsey, 1991; Linn, Clement, Pulos, & Sullivan, 1989; Koumaras, Psillos, & Tiberghien, 1989; Saxena, 1992; Scharmann, 1989, March; Targan, 1989; Westbrook, Rogers, & Marek, 1990, April; Zeidler, & McIntosh, 1989, March). In the above studies of specific concepts, such concepts or misconcepts are addressed using so called conceptual change teaching strategies. Such a common view of conceptual change is pervasive in recent research and is in stark contrast to what might be expected of research based upon the theoretical frameworks of George Posner and Ken Strike and of Susan Carey.

In addition, the object and working basis of the common view of conceptual change — that of concept — is rarely defined. I found no explicit definition of concept in this conceptual change literature. Within the constructivist science education literature, however, the driving definition behind the common notion of conceptual change appears to involve seeing concepts as propositions (Novak & Gowin, 1984). Such a focus of conceptual change instruction on propositional knowledge contributes to (a) a conflict

with the intention of conceptual change theory and (b) the establishment of, what I consider to be, a faulty assumption about the nature of (children's) understandings.

An obvious conflict is immediately apparent when the notion of a specific concept is compared with that of a broader conception or personal theory. Such concepts are plentiful, whereas broader conceptions are not. This contrast signifies a fundamental conflict with the notion that conceptual change is not a common occurrence, since few such structures fit the definition of being theory-like in nature. Applying conceptual change instructional strategies to simpler concepts or propositional knowledge trivializes the theoretical impact and practical notion of conceptual change. The term "conceptual change" is threatening to become a label describing instruction for getting children to learn the right answer, which is a new label for the same old thing (teaching for content acquisition). On the other hand, Strike and Posner's (1992) conceptual change theory is more concerned with describing the conceptual ecology of individuals and how we might begin to understand the way in which more global changes, akin to changes in allegiance to a particular belief, take place.

The "trivialization" of conceptual change also leads to the second point about the establishment of a faulty assumption. A number of papers have begun to discuss conceptual change as *replacement* (Gil-Perez & Carrascosa, 1990; Gunstone, Gray, & Searle, 1992; Hewson, 1981; Rowell, Dawson, & Lyndon, 1990; Saxena, 1992) and *restructuring* (Carey, 1985, 1986; Driver, 1989; Duschl & Gitomer, 1991; Gunstone & Northfietd, 1986, April; Hashweh, 1986; Hewson, 1981; Vosniadou, 1988, April). Both of these views of the process of conceptual change take on an objectivist[1] and mechanistic character. Conceptual knowledge is viewed as a concrete entity separate from the experience of the individual, or, according to Johnson (1987), as disembodied objective representations. Such a view gives rise to a structural metaphor that describes conceptual knowledge. Such a structural metaphor for human understanding is ultimately problematic. The notion of replacement is a particularly good example of such a problem. Replacement suggests that an individual's knowledge can be manipulated like data or programs in a computer. One understanding can be replaced by another with no recollection of the previous one. In the same regard, restructuring describes a process that results in a new understanding with no evidence of the previous one. Such a structural metaphor for conceptual change can be described in another way: knowledge is made up of building blocks which we can add to and end up with a completely new structure. Although this metaphor is convenient, it is problematic.

From personal experience, all of us can more than likely recall some old conceptions and understandings that did not match scientific ones. If the structural metaphor adequately describes learning and conceptual change, then we would not be able to recall these old conceptions. "Forgetting" these old conceptions is not a matter of having replaced or restructured them, but is a matter of not being able to access that information because of displacement, interference, or lack of use or decay. In fact, remembering a number of alternative explanations, understandings, or beliefs may be appropriate. Each alternative understanding may be appropriate and useful in a different situation or context, or may play a role in opening up an alternative explanation within a scientific context. A concept that is not in line with the accepted scientific one may be a useful concept to develop in a fictional story or artistic creation. For

example, the comment by a young child that an earthworm she was watching was "wagging it's tail" (Bloom, 1990) is not correct biologically. Earthworms do not have tails. Yet such a notion can be a powerful source of material for writing a children's story, a fable, or whatever.

In another example, an ornithologist by the name of Frank Heppner (October, 1972; June 22, 1992; personal communications) put forth a hypothetical explanation of bird flocking behavior as ESP. Such an alternative explanation was not one that he would have accepted several years prior to this, but as the more obvious explanations were eliminated the ESP explanation provided a potentially fruitful avenue for investigation (he conceived of ESP as some sort of biological radio wave-like transmission). In this instance, the alternative explanation provided a useful framework within the scientific context.[2] Since that time, a new explanation has emerged replacing the ESP explanation.[3]

Although the structural metaphor (and assumption) has been useful in providing a framework for organizing our ideas of learning, it falls short of furnishing a comprehensive working model. In addition to the two previous examples about accommodating alternative perspectives, the structural metaphor does not take into account other aspects of cognition that affect the meaning-making processes of individuals. These other aspects of cognition include, (a) emotions, (b) values, (c) aesthetic sensibilities, (d) interpretive and belief frameworks, (e) personal or episodic memories and images, (f) metaphors (Bloom, 1990; 1992a; 1992b), and (g) image-schemata (Johnson, 1987; Lakoff, 1987). Each of these aspects of cognition play a significant role in the way we make sense of our perceptions and other information we confront, in the way we make inferences, and in the way we categorize objects and other information (Bloom, 1992b; Lakoff, 1987). In general, the structural metaphor falls short in taking into account the multidimensionality and complexity of human meaning-making.

What Does Conceptual Change Mean?

In the earlier theories of cognitive development and conceptual change as formulated by Piaget, Vygotsky, Bruner, and Werner, they all concentrated on the classical view of category as concept. Although each of these theoretical perspectives differed in their specific mechanism, each one suggested a global shift in the organization of conceptual structure at a certain point in a child's development (Keil, 1989). Keil describes Vygotsky's view of conceptual change as focusing on a shift from categories based on a large number of similar features (spontaneous concepts) to categories based on one or two principled features or dimensions (scientific concepts). Similarly. Werner described change in concepts as going from holistic to analytic or diffuse to articulated. Both Piaget and Bruner focused on shifts from concrete to abstract. In each of these approaches, conceptual change involved the restructuring of categorizing schemes. However, such restructuring could only take place when appropriate thinking skills were available developmentally.

In more recent discussions of conceptual change (Carey, 1985; Posner, et al., 1982), the term conception, although similar to categorization scheme, differs in its extent. Posner I and his colleagues' definition of conception as a central organizing factor appears to take on a much broader meaning; one that is closer to the sense of Lakoff's (1987) conceptual systems, which are anchored in personal

experiences (physical and social), metaphors, metonymic exemplars, and gestalt or image-schematic views. In Carey's and Posner's views of conceptual change, theory shift (scientific revolution) is the primary analogy on which personal conceptual change is based. Another distinction from earlier views of conceptual change is that conceptual change from a contemporary perspective is not based on developmental criteria. Such a distinction is derived from the theoretical perspective of children's science (Gilbert, Osborne, & Fensham, 1982) or learning as a generative process (Osborne & Wittrock, 1983), which has its roots in the work of Kelly and Ausubel. Essentially, this perspective sees children as actively constructing knowledge by making interpretations and inferences from information they perceive. Complex thinking is more dependent upon a child's prior experience and knowledge than on developmental stages. Such a view is evident in what Hewson and Thornley (1989) and Posner, Strike, Hewson, and Gertzog (1982) explain: conceptual change is a highly personal process that leads to profound changes in conceptual understanding.

Carey (1985) contends that in order to determine if conceptual change has taken place, concepts must be analyzed within the framework of the theories in which they are embedded. Such theories-children's theories--are referred to as theory-like structures. These structures need to be "relatively few in number and ...distinguished from other conceptual structures along the continuum of explanatory depth" (p. 201). She admits that her arguments for conceptual change in childhood depend "upon these two propositions being true" (p. 201). What differentiates theory-like structures from other conceptual structures? For Carey, the differentiation is one of degree with no dear distinction. Is such a differentiation adequate as a basis for determining what is and what is not conceptual change? In fact, can such theory-like structures be compared to formal scientific theories to warrant the initial comparison of conceptual change to theory change in scientific communities?

The problem is, if children's concepts are to be compared to theories, do these concepts and theories share the same characteristics? This question points to the tension inherent in the comparison between cognitive psychology (children's concepts and learning) and philosophy of science (theories and theory change) and to problems inherent in a basic structural assumption derived from such a comparison (that there is some physical entity, "concept" or "conceptions," which can be "restructured" or "replaced").

Duschl, Hamilton, and Grandy (1990) have outlined significant tensions between the perspectives of epistemology and cognitive psychology. One such tension involves the notion of knowledge. Epistemologically, knowledge is “...true and justified" (p. 234), whereas from a psychological point of view knowledge is whatever is represented mentally. However, the tension is not simply between epistemology and cognitive psychology. The intent of curricula is for students to learn formal, epistemologically-based knowledge. Such an intent appears to have confounded the way psychologists view cognition. Since the supposition is that children will learn formal knowledge, psychologists go about the task of investigating how children learn formal knowledge. The cognitive psychologist's task becomes one of comparing formal knowledge structures to what children "know" (Bloom, 1992b). The focus of such research is on the formal or semantic knowledge of children. With the advent of constructivism,

psychologists and other researchers interested in children's learning have begun to appreciate that children construct their own versions of knowledge. However, the dominant view is still one of seeing children's learning as acquiring formal semantic knowledge. The influence of the highly organized and semantic characteristics of formal knowledge from the philosopher's view has carried over to the way children's personal knowledge is represented.

Such a framework for representing children's knowledge has influenced the comparison of conceptual change to theory change in science. Theory change, however, is a social process that involves distributed intelligence in a context of rationality, formal logic, and written discourse. In the same way, formal knowledge is the product of a great deal of highly rational thinking over a long period of time by many individuals. The emotions, values, interpretive frameworks, metaphors, and physical-social categorizations that originally may have played a part in developing the insights and hypotheses leading up to present day knowledge have long since been omitted from formal knowledge descriptions Although children operate in a social context with potential use of distributed intelligence, their everyday cognition does not necessarily reflect the kind of formal rationality evident in the theory changes of scientific communities (for further commentary of this issue see: Bloom, 1992a; West & Pines 1983).

As discussed previously, the basis fo the structural metaphor of conceptual change is not very different from the previous goal of "traditional" teaching that the teacher transmits knowledge, which in turn is retained or "learned" by students. In either case, the formal knowledge structure of the discipline or domain is seen as a model for students' personal knowledge. The fundamental problem with this view of conceptual change has to do with how we view learning. Learning is acquiring concepts, which are then analyzed according to their propositional structures and their categorical structures. Is this an adequate explanation of learning?

Both Burner (1990) and Shweder (1991) consider narrative as a more useful framework for understanding learning. Shweder explains:

> To say what something is, taxonomically, is to say what it is not, to say what it is a kind of, and to point to instances of it. It is to subsume it as a particular example of something more general and to generalize it, so as to turn something more particular than it into its example. To say what something is, narratively, is to describe its origination ("once upon a time") and its density (its aim, purpose, or function) and to comprehend its current status, in the her and now, as part of a longer story of strings, achievements, obstacles, growth, adaptation, failures, dormancy, or never-ending cyclical return. (p. 76)

Bruner (1990) suggests that folk psychology, which uses narrative rather than concept to organize knowledge and experience, is a more constructive way of trying to understand how people think and create meaning. Narrative, through "… its sequentiality, its factual 'indifference,' and its unique way of managing departures from the canonical…" (p. 50), can organize information in ways that are not categorical or hierarchical. According to Bruner, cultural psychology (which is interested in folk psychology) takes into consideration individuals' ideas about their mental states (about their folk psychology) and focuses upon action within a sociocultural setting. The two major points here are (a)

that knowing and learning, at least in part, are narrative and (b) that knowing and learning are inextricably linked to sociocultural contexts.

Narratives are a way of personalizing, interconnecting, and enriching our understandings of the world. Although categorization schemes play a role in understanding our world, they appear to work in the background and serve as a source of material for our narratives. In citing Polanyi (1958), Martin and Brouwer (1991) contend that personal narratives form the basis for understanding formal or paradigmatic science; how scientists actually do science, including emotional and aesthetic aspects. Martin and Brouwer see the aesthetic as a foundation for narrative as a way of knowing and understanding science. The authors refer to "personal science" as that which incorporates the richness of a narrative way of knowing.

Sociocultural Contexts

Sociocultural contexts involve shared meanings among members of a specific group. Groups of various sizes and differing membership characteristics can overlap in their membership. Any single individual can belong to several different sociocultural groups. In other words, many sociocultural contexts affect any particular individual. From the most general level of "human beings" to very specific levels, such as those individuals living in a particular neighborhood, each sociocultural context affects people's cognition in different ways and to varying degrees.

Such sociocultural contexts are created, maintained, and altered by the individual members, and, at the same time, influence, maintain, and alter the group members' individual cognitive contexts (cognitive contexts refer to how individuals make sense of the world, create personal meaning, make decisions, etc.) (Bloom, 1992, May). Sociocultural and cognitive contexts are inseparably intertwined. Neither context is "by nature intrinsic or extrinsic to the other" (Shweder, 1991, p. 100). Shweder (1991) refers to the psyche or cognitive context as an intentional person and to culture or a sociocultural context as an intentional world:

> The principle of intentional worlds...asserts that subjects and objects, practitioners and practices, human beings and sociocultural environments, interpenetrate each other's identity and cannot be analyzed into independent and dependent variables. Their identities are interdependent; neither side of the supposed contrast can be defined without borrowing from the specifications of the other, (p. 74)

He adds that "...no sociocultural environment exists or has identity independently of the way human beings seize meanings and resources from it..." (p. 74). Meanings exist within sociocultural contexts as sociocultural contexts of meaning. These meanings are in turn extracted by individuals or cognitive contexts and are modified into individuals' contexts of meaning. Shweder's (1991) notion of cultural psychology is based on two premises: (a) the principle of existential uncertainty (intentional person), which deals with individuals' search for meaning in the sociocultural environment and (b) the principle of intentional worlds (culture), which deals with the inseparability of individuals and their actions within a particular sociocultural environment.

The degree to which different sociocultural contexts affect the cognitive contexts of individuals and vice versa is dependent upon a number of factors. Hofstadter (1979) discusses this aspect of the effect of physical and sociocultural contexts on cognitive contexts:

> We build up our mental representation of a situation layer by layer. The lowest layer establishes the deepest aspect of the context-sometimes being so low that it cannot vary at all. For instance, the three-dimensionality of our world is so ingrained that most of us never would imagine letting it slip mentally. It is a *constant* constant. Then there are layers which establish temporarily, though not permanently, fixed aspects of situations, which could be called background assumptions-things which, in the back of your mind, you know can vary, but which most of the time you unquestioningly accept as unchanging aspects....Then there are "parameters": you think of them as more variable, but you temporarily hold them constant. There could be--and probably art several layers of parameters. Finally, we reach the 'shakiest' aspects of your mental representation of the situation--the variables, (p. 644)

Those sociocultural contexts exposing and communicating the most fundamental assumptions appear to make the most enduring effects on individuals' contexts of meaning, Context of meaning describes the array of factors that contribute to a particular meaningful perspective or understanding. Contexts of meaning include semantic (formal) knowledge personal experiences, metaphors, interpretive frameworks, and emotions-values-aesthetics (see other papers for more details: Bloom, 1990; 1990, April; 1990, June; 1992, May; 1992a; 1992b). The variety, nature, and degree of the effects of sociocultural contexts upon individuals contribute to the way in which individuals think, act, and create meaning, as well as to the extent to which individuals can understand varying or multiple perspectives. The extent of understanding varying perspectives is directly related to the issue of conceptual change.

Conceptual Change or Contextual Flexibility

Learning and conceptual change can be looked at as changes in contexts of meaning both personal and sociocultural. The inability to understand another perspective, such as a scientific explanation or a particular cultural group’s point of view, can be seen as a matter of contextual rigidity. Such contextual rigidity is the inability to take on or understand multiple perspectives. Contextual flexibility, on the other hand, refers to the ability to understand another perspective. Such flexibility does not necessarily mean that an individual changes allegiances (from one contextual perspective to another), but it does mean that an individual is able to understand another perspective. Shweder (1991) discusses this sense of change, but with a different end:

> According to the premises of cultural psychology, even the transcendent realities portrayed by scientists are part of intentional worlds and cannot really take us beyond our mental representation of things.... transcendence and self-transformation are possible but only through a dialectical process of moving from one intentional world into the next, or by changing one intentional world into another, (p. 99)

Our expectations of conceptual change teaching are that children's notions of how certain phenomena work will be replaced by (will move from one intentional world into another) a scientific one. I am not suggesting that children cannot come to change allegiances to scientific beliefs. However, I am suggesting that one cultural context or intentional world is not replaced by another. Rather, one's allegiance can change, but the previous context (or conception) does not disappear. Although Shweder claims that one can move from or change one intentional world to another through a process of reasoning, he offers no empirical support for such a claim. If as he claims, psyche and culture make up each other, then it would be difficult for a process of reasoning to move from or change a culture. When an individual moves from one culture into another, the original cultural representation is not replaced within that person's own cognitive context (psyche). The cognitive context, however, will change (but not change *into* a new context) as the new cultural context is incorporated along with the old.

In most societies, we (including children) are influenced by and are influencing a large number of sociocultural contexts. From a small social context of a group of friends or a classroom to larger cultural contexts of ethnic group, religion, community or region, and national society, each individual contends with representing the dynamic interplay between each contextual demand or influence. These representations and interplay among different contexts occur within a personal cognitive context. The personal cognitive context provides the means for achieving contextual flexibility, for understanding our world from multiple perspectives. On the other hand, our personal cognitive contexts can become "arthritic" in the sense of perpetuating contextual rigidity. New or different ideas are rejected without attempting to understand them.

Understanding multiple perspectives or achieving contextual flexibility seems to be based in metacognitive ability, in the ability to understand one's own thinking. Throwing out another perspective on emotional grounds and without considering it is due to a lack of understanding of how our own thinking works. Understanding multiple perspectives requires an understanding of our own cognitive context, of our own thinking. As we reconsider our conceptual or perhaps narrative understanding of learning, we can view conceptual change more as conceptual integration or the learning of and about different perspectives or contexts of meaning.

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Notes

[1] See Johnson (1987), pages xix - xxxviii, for a thorough treatment of objectivism.

[2] According to Heppner, it is interesting to note that putting forth the ESP explanation was ir fact a way to maintain the prevailing anthropomorphic framework. The assumption at the time was that bird flocks had a leader (which made sense from a human point of view). ESP maintained this idea by providing a rational way of maintaining this perspective. The flock leader could emit some sort of biological radiation that the flock could react to much more quickly than it could to other types of visual or auditory signals. Such other signals had been discarded as potential means of communication through a series of investigations. (Heppner, June 22, 1992, personal communication).

[3] For further information on this new explanation, which is based on a computer model and removes the need for a "leader", see: Heppner, F., & Grenander, U. (1990). A stochastic nonlinear model for coordinated bird flocks. In S. Krasner (Ed.), *The Ubiquity of Chaos, Publication 89-15S* (pp. 233-238). Washington, DC: American Association for the Advancement of Science.