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Contexts of Meaning and Conceptual Integration: How Children Understand and Learn

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Abstract

This chapter explores the contention that meaning as defined by epistemology and cognitive psychology does not capture the variety and richness of meanings derived from experience. These two disciplines describe meaning as being propositional or semantic in nature. The tension discussed in this chapter occurs between this sense of meaning and a different notion of meaning that emerges from data drawn from several recent studies on the perspectives of children. The notion of "contexts of meaning" suggests that meaning includes not only semantic knowledge but also episodic knowledge, the products of various mental processes, interpretive frameworks, and emotions, values

and aesthetics. The result is a view of meaning that is dynamic, a view that can accommodate multiple perspectives and understandings.

Duschl, Hamilton and Grandy's (this volume) focus on the tensions between epistemology and cognitive psychology is a critically important issue that should be brought to the forefront of cognitive research and curriculum planning and implementation. The point I would like to explore in the present chapter is the issue of "meaning." The tension discussed in this chapter is one between current thinking about meaning in philosophy and psychology (i.e., meaning is propositional and semantic in nature) and the notion of meaning derived from data drawn from several recent studies on children's perspectives. Initially, I will provide a brief overview of the relevant research and how it relates to my view of the tension. This section will be followed by an examination of the data from my own research: "contexts of meaning." The final section will discuss the implications of contexts of meaning and the concomitant tension for educational research and curriculum development.

Theoretical Background

Traditionally, epistemological concerns have served as the basis for designing curricula and instruction in science education. Formal knowledge or the knowledge of the discipline has determined not only what was to be taught but also how such instruction was to be delivered. According to Pines and West (1986) "formal knowledge is a product of planned instruction, is someone else's interpretation of the world, someone else's reality [and] is approved by the consensus of adults who are usually older and more highly respected than the students" (p. 586). In other words, formal knowledge is the concern of epistemology. The intended outcome of instruction based on formal knowledge has been that students will learn what is taught in a form close to that of the structure of knowledge of the discipline.

According to Duschl, Hamilton, and Grandy (this volume), philosophers are concerned with formal knowledge, while cognitive psychologists are concerned with what and how individuals know. They see this as a fundamental tension, that is, what philosophers see as beliefs, psychologists see as knowledge. However, as suggested in the above paragraph, science education is concerned with how well individuals learn formal knowledge. When teachers, students, and curriculum come together, the tension between formal knowledge and cognition becomes confounding to the educational enterprise.

However, the tension is not simply between epistemology and cognitive psychology. The intent of curricula is the acquisition of formal 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." 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. Evidence of this influence can be seen in the work of numerous researchers in psychology and science education (Champagne & Klopfer 1984; Driver & Bell 1986; Finley & Stewart 1982; Gilbert, Osborne & Fensham, 1982; Hills 1989; Kiel 1989; Markman 1989; Novak 1987; Pope & Gilbert 1983; White 1988).

The conflict or tension becomes one between "meaning" according to the presuppositions arising out of epistemology and what actually constitutes meaning for children. The view of what is meaningful to children comes from the perspective of formal knowledge structures. Such a perspective is evident in Ausubel's (1963) classic work and has been reiterated more recently by Novak (1987), who suggests that human constructivism

> is an effort to integrate the psychology of human learning and the epistemology of knowledge production [by placing] emphasis on the idea that in both psychology and epistemology we should focus on the process

> of *meaning making* that involves acquisition or modification of concepts and concept relationships. (p. 356)

Both Ausubel and Novak make an explicit connection between formal knowledge structures and meaningful learning. Meaning, from such a perspective, is based on formal knowledge.

The notion of "meaning" from both a disciplinary and an information processing psychology point of view is that meaning is propositional. Meaning is semantic in nature and as Macnamara (1982) contends, in psychology, meaning and concept are rarely distinguished. If

information about a certain topic is related or linked together according to logical principles and if that information is understood, then it is meaningful to the people who understand it. For example, if we were to consider an exclusive definition for *amphibian*, we would encounter the following: (a) amphibians are vertebrate animals (which would be linked to characteristics of both vertebrates and animals), (b) amphibians lay eggs underwater, (c) amphibians have a three-chambered heart, (d) amphibians have moist skin, (e) and so forth. If someone were to understand these and associated propositions, then "amphibian" would have meaning for that individual. However, is such a notion of meaning a complete representation of what actually constitutes meaningful understanding to children or adults? Is there more to personal meaning than sets of related propositions? Is personal meaning governed by the rules of formal logic?

The answers to such questions appear to lie beyond the bounds of a purely semantic view of meaningful learning. Pepper's (1970) work with world hypotheses has influenced some researchers' work with the influence of world views on learning (Anderson & Kilbourn 1983; Roberts 1982b). Other researchers (Cobern 1988, April; Gauld 1987) are exploring the role of beliefs (including a distinctively different sense of world views) in learning science. Still others have looked at belief systems as cultural phenomena that influence learning in terms of cognitive ecology or the social and environmental context of learning. Mariana Hewson's (1988) research looked at how children in developing African nations constructed scientific knowledge according to prevailing cultural beliefs. Berlin, Breedlove, and Raven (1966) considered the social and environmental context of learning in their study of folk taxonomies. Although the inclusion of beliefs and other epistemological commitments provides a broader understanding of meaningful learning, the predominant view of conceptual ecology is still primarily semantic.

Even though beliefs appear to be another aspect of semantic knowledge, the notion of beliefs as guiding frameworks for the construction of knowledge may offer a more productive way to view their function. Take for example, Gilbert, Osborne, and Fensham's (1982) discussion of children's science. Egocentric, anthropocentric, anthropomorphic, zoomorphic, and other viewpoints are treated as principles that guide children's thinking processes. The view that such guiding principles affect children's thinking about science topics is of importance in understanding how personal meaning is constructed.

Beliefs and belief frameworks are frequently shared among individuals in a particular cultural context. Such a notion leads us to the conception of meaning as imbedded in a social context. Socially embedded

meaning has been of interest to anthropologists and sociologists of education but has not been given much consideration in the constructivist circles of science education. From an anthropological view, Burtonwood (1986) discusses how the Kuhnian sense of paradigm can be applied to learning or socialization within specific cultural settings. Such a paradigmatic view of learning within social contexts provides an intriguing demonstration of how contradictory or anomalous conceptual commitments can lead to stresses on the social structure or to revolutions. From a constructivist perspective, Hewson's (1988) discussion of the difficulties encountered by native African children when their culturally embedded beliefs clash with Western science beliefs is an appropriate example of the stresses confronted on a cognitive level when two socially embedded meanings come into conflict.

Although personal meaning is strongly influenced by the sociocultural context, individuals use resources other than semantic information, belief frameworks, and the sociocultural context to construct meaning. Emotions are a critical component of meaning. Both Hofstadter (1979) and Bruner (1986) consider emotions as "triggers" of meaning. Triggers function in a similar way to Bateson's (personal communication, July 21, 1975) notion of context markers. Emotions, from a contextual point of view, can trigger specific meanings.

The idea of context begins to take on somewhat different characteristics from the sense of sociocultural contexts discussed previously. According to Bateson (1979), context is "pattern through time" (p. 15) or "a little knot or complex of that species of connectedness which we call relevance" (p. 14). In addition, "'context' is linked to another undefined notion called 'meaning.' Without context, words and actions have no meaning at all" (p. 16). Context determines meaning, in terms of both sociocultural contexts and a variety of other potential contexts. In fact, multiple contexts can be

operating concurrently. Both Bruner (1986) and Bateson (1972) see the effect of the multiplicity of contexts as an individual's ability to hold multiple perspectives of his or her world. Bruner explains his notion of multiple perspectives in the following way:

> We know the world in different ways, from different stances, and each of the ways in which we know it produces different structures of representations, or, indeed, 'realities.' As we grow to adulthood (at least in Western culture), we become increasingly adept at seeing the same set of events from multiple perspectives or stances and at entertaining the results as, so to speak, alternative possible worlds. The child, we would all agree, is less adept at

> achieving such multiple perspectivesalthough it is highly dubious that children are as uniformly egocentric as formerly claimed. (p. 109)

Each perspective represents a different context in which phenomena are understood or a different "context of meaning." Such contexts of meaning can overlap producing a multiplicity of meaning around any given phenomenon. The following section elaborates on such contexts of meaning in light of data from two recent studies.

Contexts of Meaning

The idea that a child's understanding takes on the characteristics of contexts of meaning first developed as I sifted through mounds of interview transcripts from a study with two classrooms of twenty-three first-, second-, and third-grade children. One part of this study using interviews with ten children is described elsewhere (Bloom, in press). In a series of more recent studies with fifth-grade students, similar semi-structured interviews with nine children as well as a variety of other tasks with twenty-four children explored the characteristics and dynamics of contexts of meaning (Bloom 1990, April; 1990, June). In two of these studies, one set of interviews centered around observations of live earthworms. Earthworms, as it turned out, had not been the object of formal study in the classroom, but were familiar to all of the children. For the sake of clarity in the following discussion, the children's pseudonyms have been arranged according to grade level. Grade 1 children's names begin with *A*, while grade 2 names begin with *B*, grade 3 names begin with *C*, and grade 5 names begin with *E*.

In order to establish a descriptive basis for discussing contexts of meaning, I have developed a typology from the data of the two studies. The typology contains four general divisions: (a) knowledge; (b) mental processes; (c) interpretive frameworks; and (d) emotions, values, and aesthetics. In addition, the divisions are subdivided into a

number of components, some of which contain further subcomponents (see table 6-1). As we explore this typology in more detail, it is important to realize that children's context of meaning are not static. They are dynamic systems of continuously changing information.

In the original study (Bloom, in press), the typology was established to describe patterns evident in the data. The definitions of some of the category labels are relatively standard, such as semantic and episodic knowledge. However, the other categories warrant brief explanations.

Table 6-1
A typology describing the components of the context of children's thinking in biology

Division	*Components*
Knowledge	Semantic knowledge
	Episodic (experiential) knowledge
Mental processes	Inferring
	Perceiving
	Describing
	Explaining
	Comparative processes
	Generating metaphors and analogies
	Comparing
	Discriminating
Interpretive Frameworks	Anthropocentrism
	Anthropomorphism
	Zoomorphism
Emotions, Values, and Aesthetics	

Mental processes are obvious at one level, especially considering the amount of research devoted to the description of such processes (e.g., inferring, elaborating, recalling, perceiving, etc.). However, the important notion is that such processes are constantly changing the nature of what children understand by changing knowledge and by adding new information. New information added to an individual's context of meaning may be the product of a specific process, such as metaphors. Interpretive frameworks were originally referred to as "belief frameworks," but "belief" is not an adequate descriptor. The confusion between the psychologist's and the philosopher's definitions of belief detracts from the intended operational nature of the

typological category. Interpretive frameworks describe how a certain point of view, belief system, or knowledge set influences the operations of various mental processes. For example, anthropomorphism may influence the way an inference is made. The subcomponents of anthropomorphism and zoomorphism both refer to the process of transferring the characteristics of human's and other animals' (respectively) to the object or organism at hand. Anthropocentricism, on the other hand, concerns the view that focuses upon human needs, desires, concerns, and so forth. The category of emotions-values-aesthetics was formulated to describe what appeared to be the basis of various statements. These aspects have been combined because of the difficulty in separating them

as they manifest in children's speech. A child may be disgusted by earthworms, think they are ugly, and not like them. All three aspects of emotions, values, and aesthetics are strongly associated. Separating them makes little sense in terms of the operationalization of contexts of meaning. Each of the typological categories will be elaborated upon in the following discussion.

The major component of the typology responsible for the dynamic quality of contexts of meaning is mental processes. Mental processes not only construct semantic knowledge but also generate new ideas from previous knowledge and new experiences. For example, Emily's observations of an earthworm show a progression of perceptions that lead to the formulation of an inference:

> now it's turning green a little bit it looks like they kind of change colors as they move the dark pink and there's red and there's green and there's a brown and there's that purple color there's even that orange I think that's the vein and then there's that ugh yellow [ring]

In another instance, Emily demonstrates how a number of ideas can be generated as explanations of a particular phenomena:

> I think that's kind of a sensor something like that so they can find their way around well, it looks like it because it's going around and around it looks like it's kind of sniffing to see what's there [Interviewer: Do they have noses?] I think it's kind of like cats' whiskers you know they don't smell but they feel they've got kind of a nerve maybe maybe that line in there maybe that's a nerve connecting to the head

In this latter example, we can see how Emily notices a particular behavior and infers that a specific structure has an associated function. At first she thinks of this function as sniffing, then she compares the function to that of cats' whiskers. From this comparison she infers the existence of a nerve, which she thinks she sees as a line down the center of the body. In both examples, Emily is actively constructing

knowledge from previous knowledge and her new experiences. The meaning attached to this newly constructed knowledge extends beyond the evident semantic information. The notion that earthworms have " a sensor so they can find their way around" suggests a zoomorphic, if not anthropomorphic, framework of intentionality. Such a connection is meaningful. In the same way, the comparison to cats' whiskers is potentially

laden with meaning stemming from personal experiences with cats.

Another powerful influence on the construction of meaning is a combination of emotions, values, and aesthetics. These three aspects of contexts of meaning have been combined because of the difficulty in clearly distinguishing them. For instance, at the beginning of the interview with Elliot, he broke an earthworm in two while digging around. He was quite upset. As he continued to look for more earthworms, he proceeded with greater caution saying, "don't want to [break one] this time." Near the end of the interview, he mentioned that fish eat earthworms and "for fishing they make good bait [Interviewer: Do you go fishing?] yeah [5] I use bread though" ("5" refers to length of pause in seconds). In a similar way, Andy comments that fishing is " sort of bad because he's [earthworm] sort of killable eaten by fish." Cindy mentions that, "I'm afraid I'm going to kill it," then goes on to say, "I don't feel like doing this I keep killing things." In all three cases, their sensitivity towards earthworms appears to based on a particular set of personal values that are closely linked with emotions. Such strong connections with emotions and values impact on the way children proceed with tasks and on how they integrate and utilize new and prior knowledge.

Aesthetics and the lack of aesthetic appreciation are frequently evident in children's conversations about earthworms. Adam talked with a lot of confidence in his own knowledge of earthworms. His excitement carried through the whole session. His aesthetic appreciation of earthworms is demonstrated in the following excepts: (a) "they are really neat ," (b) " the fatter ones are pretty," and (c) " they also hear with their mouth isn't that neat." By contrast, Curtis did not have an aesthetic appreciation for earthworms. Some examples of Curtis's comments about earthworms include, (a) "I know a lot about worms but I don't like them," (b) " they are slimy 'cause they look funny," and (c) " a snake is cute [worms] are ugly." Becky, on the

other hand, changed from being afraid of earthworms to liking them: " used to be scared of worms felt they were going to slither on me [now] they are quite cute." In each of these cases, emotional reactions to earthworms are closely tied in with an aesthetic appreciation or lack of appreciation.

The previous examples point not only to the intermingling of emotions, values, and aesthetics, but also to the importance they play in influencing the construction of meaning. For example, in addition to Cindy's fear of killing the earthworms she remarks that " they are depressingly see-through." The fact that she can see what is inside the

earthworm has a certain amount of impact on her. Such an emotional link with an observation is meaningful to her. In a similar way, Andy's comment that "they're both boy and girl mixed up yuck" reflects prior knowledge that obviously had considerable valuational and emotional impact. The semantic knowledge associated with emotions and values was particularly meaningful to him. Such links with emotions, values, and aesthetics create extremely rich and diverse contexts of meaning.

Frequently in combination with emotions, values, and aesthetics, interpretive frameworks add to the richness and power of children's contexts of meaning. By placing the qualities of humans or of other animals onto other objects (earthworms in the present discussion), children create personally meaningful constructs. An almost classic example of such a construct is Beth's statement that the earthworm is "wagging it's tail." Although earthworms do not have tails, their appearance is suggestive of tails. Tails are not only long, thin, and round, but are commonly known to wag. In addition, wagging tails connote an array of emotions, depending on the animal. In a similar way, Andy's comment that a particular earthworm " is hunting for dirt" suggests that earthworms exhibit the intentional behavior of hunting. The behavior of the earthworm is embedded in a meaningful context of associations, like a cat hunting its prey or a squirrel hunting for a buried nut.

The meaningful connections displayed by anthropomorphic statements are even more powerful in that children can personally identify with the earthworms. Amy's comment that one earthworm is " playing with all that fuzzy wuzzy " suggests a behavior (playing) which is familiar to her. When Andy says that an earthworm " needs to be careful of birds," his understanding that birds eat worms is enriched by attributing earthworms with cognizant abilities: "If you know you can be eaten by birds, then you had better be careful." The emotions alluded to in such anthropomorphic and zoomorphic

statements are again a strong component of the contexts of meaning.

Although the effect of mental processes (perceiving, inferring, etc.) on the construction of knowledge and meaning receives considerable treatment in the literature, one aspect of mental processes is worthy of further discussion. The generation of metaphors and analogies are a significant contributor to contexts of meaning. Even among very young children, the generation of metaphors is a common occurrence. Some examples of the metaphors used by grade 1 and 2 children include, (a) "Slinkies" as a descriptor of movement (Amy, also used by Emily), (b) "jump rope" as an imagined action (Amy), (c) "scooter boards" as a

descriptor of movement ("slipping on ice like ") (Amy), (d) "trapeze" as a descriptor of action (Amy), (e) "playing" as an anthropomorphic descriptor of action (Amy), (f) "clothes" as an anthropomorphic comparison of skin to the function of clothes transposed to skin as clothes (Amy), (g) "drill" as a descriptor of digging action (Adam), (h) "springs" as a descriptor of movement (Alex), (i) "dragon's mouth" as a descriptor of the structure of the worm's mouth (Andy), (j) "big swords" as a descriptor of shape (Becky), and (k) "Jell-o" as a descriptor of touch (Bonnie). In each of the previous examples, metaphors add to the dimensions of contexts of meaning by extending the breadth of connections.

A different type of metaphor occurred with two children who imagined themselves as an earthworm or other organism. In response to a question about what the heart does, Cindy says, "I don't know about my body [laughs] well I don't know about my worm body [laughs] it moves the same way so it probably has the same inside." She starts off by taking the position of being the worm and then infers that humans and earthworms have similar structures. Whether or not such a metaphorical transposition aided the inferential process is uncertain. From the moment Evan sat down for the interview he concerned himself with what it would be like to be a tiny organism: "have you ever tried thinking about what it would be like to be a bug?" A few moments later after finding an earthworm, he continued, "what does it feel like to be a worm under the ground all the time [after a brief diversion] I just think it would be dark it would be a bit boring I think it would be lonely." He continued with a discussion of how it " feels weird to be a human being." Flipping back and forth, Evan's particular feelings were difficult to distinguish from those imagined of the earthworm. At the very least, such transpositions between oneself and another organism appear to be very powerful vehicles for developing personal meaning.

Up to this point we have examined various aspects of the notion of contexts of meaning. I suspect that other components could be added to the typology. However, the major point is that children's, indeed human beings', understanding of their world is far more complex than what most research leads us to believe. Although propositional knowledge is a major component of children's construction of meaning, other components and processes play important roles in meaning-making. The products of some mental processes and other context of meaning components are frequently not considered relevant to the development of scientific knowledge. For instance, anthropomorphism and emotional statements, such as "it *won't let* me pick it up" or "pretty *scary* for

the worm," are discouraged among science teachers and scientists. However, from the point of view of children's understanding, anthropomorphism, emotions, and so forth are powerful facilitators of meaning-making.

Summary of Contexts of Meaning

Contexts of meaning are not strictly scientific in nature, nor are they necessarily logical or rational. Instead, such contexts point to a wide variety of associations with different types of information, beliefs (as a component of interpretive frameworks), emotions, values, and aesthetics. For example, contexts of meaning are often indicated by context markers. As discussed previously, the statement, "wagging it's tail," marks a context of meaning about "tails" and their structure and function. In the same way, heads, eyes, hunting, and so forth, point to or trigger further meaning. Heads and eyes orient the child to worms. The head and eyes deal with knowing the world, they are the essence of being alive from the child's point of view. If a worm is alive, it has to have a head and maybe eyes. The action of hunting provides a way to interpret the behaviour of worms. When the worm is moving its "head" around, it looks as if it is "hunting" and hunting is what "animals" do.

Contexts of meaning are dynamic and ever-changing arrays of information imbedded in a variety of emotions, values, aesthetics, and beliefs. The action of various processes (inferring, comparing, perceiving, etc.) continuously alter the content and meaning of these contexts. Such contexts of meaning are highly personal because of the influence of individual (episodic) experiences, emotions, values, interpretive frameworks, and so forth. Various context markers, such as "tails," may trigger similar meaning in different children, but in the larger context, in the present case "worms," each child's meaning is quite individualized and different.

If we consider children's contexts of meaning in the spirit of "alternative" frameworks by not judging their "correctness," we can begin to see how children construct and modify concepts along with associated meaning. For example, the children discussed in this chapter may not have developed any concepts of how earthworms move, yet as they examined the worms in front of them the children described what they saw. In their descriptions, the children used other concepts available to them, such as "pulling" as an explanation for how worms were able to make one part of their bodies move and then another part move. Some children made metaphoric associations with objects, such as Slinkies. Other children inferred that worms must have muscles,

because humans have muscles. In most cases, children actively sought out associations with their own experiences and previous knowledge.

Contexts of meaning expand and change as they overlap and interact with other contexts. Individual concepts clearly occur in a complex arena of interrelated concepts, emotions, values, beliefs, and so forth. Isolating specific concepts in the study of children's knowledge and conceptual change, as is being done in much science education research, can pose some serious problems. For instance, when researchers think they have identified a concept, such as "worms have tails," they label it as a misconcept or alternative concept. Such a concept is viewed as needing to be changed to conform with the scientific concept. The problems are (a) that there is a substantial amount of meaning attached to the concept, worms have tails; (b) that by not paying attention to and appreciating the significance of that meaning, we may be missing most of what a child understands; and (c) that by not working with the child's contexts of meaning that surround concepts, we will have greater difficulty helping children to meaningfully incorporate scientific versions of concepts.

Discussion and Implications

The tension between epistemology and cognitive psychology is a bit more extensive than that laid out by Duschl, Hamilton and Grandy (this volume). In some ways, the tension is more triadic: epistemology, cognitive psychology, and actual cognition. The dominant paradigm governing much of cognitive psychology is epistemological, in the sense that the logical structure and semantic nature of meaning is modeled in the way meaning is represented in cognitive psychology. The logic of this connection between epistemology and cognitive psychology is typified by Finley and Stewart (1982) in their discussion of developing artificial intelligence systems for representing meaning and knowledge:

The original purpose of these systems was to represent knowledge as it is stored in human memory. These same systems are applicable to representing the substantive structure of disciplines because both the substantive structures and an individual's knowledge are products of the same human thought processes. Expecting the substantive structures of disciplines to be greatly different from the structures of human memory would require positing different mechanisms of human thought for scientists than for other individuals. (p. 595)

The problem with Finley and Stewart's contention is that a substantial number of different mechanisms of thought are categorically ignored in developing formal knowledge structures. Although certain types of nonsemantic mechanisms may be evident in a scientist's thinking (Bloom 1988, April), evidence of such thinking would never make it into the writings of that scientist. 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 so forth 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.

In the everyday thinking of children, the same or similar rational processes operate along with emotionally driven or interpretive framework-guided processes. One child may conceptually organize his or her ideas about a topic, while another may not (Bloom 1990, April). One child may seem to rely heavily upon her emotions for interpreting information, while another child may rely upon his personal experiences (episodic knowledge). All of the cognitive processes evident from the perspective of contexts of meaning are powerful tools for creating meaning, although they may not be valid from a traditional epistemological point of view. On the other hand, such processes and their products may be valid from an artistic, literary, or other creative point of view.

Problems arise when these various cognitive processes come together to create, what Bateson (1979) calls a "muddle." In a previous study of student teachers (Bloom 1989), the conflicts between individuals' beliefs or interpretive frameworks and their formal knowledge of science confounded the way in which the student teachers viewed evolution and the teaching of evolution. The same sort of conflict was evident in the study of evolutionary biologists (Bloom 1988, April).

Even though the biologists had extensive experience and formal knowledge backgrounds, some of them were more strongly influenced by personal interpretive frameworks in terms of their inflexible approach to research and to working with alternative hypotheses.

The danger has been that as we explore children's and adults' understandings, we tend to become reductionist to the point that we miss the forest for the trees. We isolate a specific conceptual structure, while missing the greater understanding or context of meaning behind it. Conceptual change-based instruction from a perspective of knowledge that focuses on isolated and specific concepts misses a significant portion of children's constructed meaning. From a cognitivist point of

view, we must consider the complexity, variety, and interrelatedness of mental events as a whole. For instance, rather than ignore the influence of anthropomorphism in making inferences, we need to acknowledge and explore the power of this particular mechanism.

Any thinking about curriculum and instruction has to be grounded, at least in part, in a broader view of children's construction of meaning. If we consider Robert's (1982a) description of seven curriculum emphases and his suggestion for a more eclectic, yet critical, approach to science education, the approach being proffered in the present chapter is more or less aligned with his "self as explainer" emphasis. The major difference between Roberts's "self as explainer" and what I am suggesting is that we need to deal with more than children's semantic knowledge about specific objects or events and with more than the scientific understanding. As mentioned previously, we, as human beings, understand our world from many different perspectives. As science educators, not only should we help children develop a critical understanding of scientific explanations, but we should help children develop a critical understanding of other perspectives and the thinking mechanisms that contribute to their construction as well.

The earthworm wagging its tail is a useful example to consider. Rather than simply dealing with the specific concept itself, we could have young children explore what a wagging tail means. A variety of examples could be collected and analyzed, such as, the "wagging" of tails by dogs, cats, alligators, tigers, and so forth. Within this exploration the notion of how the meaning of a wagging tail varies depending upon whether you are a human being or another dog, cat, or whatever will emerge. At the same time, the idea of tail can be explored. Examples of tails could be examined. Children could try to invent their own definition of tail. In the process of testing out their definition of tail, they may realize that worms do not have tails. In that

case, the new concept, "worms do not have tails," is incorporated into the contexts of meaning surrounding earthworms along with the idea that earthworms look like tails.

Maybe what we should be concerned with instead of "conceptual change" is "conceptual integration." From the scientific point of view, some concepts, such as worms wagging their tails, are erroneous, but from a poetic or other creative point of view, the same concepts may be very powerful. Trying to replace potentially powerful but scientifically erroneous ideas perpetuates a certain scientistic presumptuousness. The power of viewing learning within the notion of contexts of meaning lies in the capacity of individuals to hold a multitude of diverse and often contradictory ideas, images, and emotions. Even young children

are capable of recognizing the differences between the ideas they hold. For example, Cindy related a tale of how snakes ended up without any legs. In short, after humans and other animals got their legs, the millipede asked for all the rest, leaving the snake with none. Afterwards I asked if she believed it and she said, "no, it's a folk tale like geese can talk."

Curriculum development could incorporate the view of multiple perspectives and multiple meanings. What is being suggested is a new and broader view of an existing idea, the integrated curriculum. The arts, the humanities, the social sciences, mathematics, and the natural sciences are all concerned with understanding our world and expressing that meaning in some way. Schools have, for the most part, clearly separated and divorced these aspects of meaning (subject matter disciplines) from individual children's experiences. Children's thinking, as we have seen, does not operate along disciplinary lines, but incorporates the seeds, if not the richness, of varied disciplinary thinking. If we want to develop this richness of thinking, then we need to rethink how we organize school curricula, how we train teachers, and how we implement instruction.

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