Conceptualizations of Nature: An Interpretive Study of 16 Ninth Graders' Everyday Thinking

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Abstract: The research reported in this article sought to provide a broader understanding of high school science students as persons by describing the personal thoughts, or everyday thinking, about a question relevant to science: What is Nature? The purpose was to gain an understanding of students' fundamental beliefs about the world on the basis that developing scientific literacy can be successful only to the extent that science finds a niche in the cognitive and cultural milieu of students. The theoretical background for this research came from cultural anthropology and the methodology was interpretive, involving student interviews. The assertions of the study in summary form were: (a) The ninth-grade students in the study tended to discuss Nature using several different perspectives (e.g., religious, aesthetic, scientific, conservationist). A rich breadth of perspectives typically characterized any one student's discussion of Nature. (b) After 9 years of schooling, however, the level of science integration within everyday thinking remained low for many of these ninth graders. In their discussions of Nature, most volunteered little school knowledge of science. They were aware of school science topics such as the ozone layer, rain forests, and the Big Bang theory. Such topics were voluntarily mentioned but usually without elaboration even when asked. (c) Science grade success was not correlated with the concepts these ninth graders typically chose to use in a discussion about the natural world. The students with the most grade success in science had not necessarily grasped fundamental concepts about Nature and science. (d) Regardless of school grade success, including school science grade success, most of the ninth graders attached considerable importance to personal experiences with Nature. Their environmental inclinations were strong. The article ends with a discussion of the implications. © 1999 John Wiley & Sons, Inc. J Res Sci Teach 36: 541–564, 1999

> The proper study of mankind is man. [Alexander Pope (18th century)]
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> You cannot study people. You can only get to know them. [C.S. Lewis (20th century)]

Alexander Pope expressed the Enlightenment ideal of broadening the Scientific Revolution to include the study of human beings not only as physical organisms but as psychological ones

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as well. The scientific study of the human being flourished and eventually spawned many new and more specific disciplines. Among these one counts the scientific study of science learning and teaching. All of this is part and parcel of modernism. Without commenting on the successes and failures of modernism, suffice it to say that in many disciplines today many scholars look to very different methods for addressing the questions they have about people and their behavior. There has come an attitude shift characterized by C.S. Lewis above. It is an attitude most clearly seen to date in feminist scholarship of which Carol Gilligan's (1982) *In a different voice* and the Belenky, Clinchy, Goldberger, and Tarule (1986) study, *Women's ways of knowing: The development of self, voice, and mind,* are excellent examples. If we may paraphrase and adapt from these scholars, there are voices of people that need to be heard if scholars intend to have a valid understanding of people and their behavior. The feminist scholars were, of course, seeking ways of making women's voices heard, but the importance of their work exceeds gender issues. The work is important for restoring the image of people as persons rather than as objects of research. The foundational perspective for the research reported here is that one must hear from science students about themselves to better understand how they make — or do not make — science meaningful. Our principal research question was: What are the thoughts that a group of ninth-grade students have about Nature? We are specifically interested in the extent to which student understanding of Nature involves concepts from science vis-à-vis other conceptual domains.

The Theoretical Framework

People are purposive, intentional beings. People are creatures of habit and yet full of surprises. People can be quite unpredictable. For these reasons and many others, it is difficult to come to know people in the sense of having a causal understanding of human behavior which was the modernist project in education. At least, this cannot be done as scientists do with moving objects such as particle or projectile motion, for example, or even with the behavior of non-human animal species. What a person can do that an object cannot is to tell you about him or herself, thus helping you to get to know this person. This is, of course, a different kind of knowing, and it suggests that getting to know a broad range of people provides an educator with exemplars of what people in general are like. "Interpretive researchers," noted Cobern (1993a, p. 936), "do not expect that the procedures of experimental natural science can ever be used to produce general laws of education. Rather, one must come to a greater understanding of what meaning is and how it is created. Similarly, the classroom environment is not to be composed of causal variables which the teacher manipulates to foster learning, but an environment mutually shaped to fit the members of the classroom, both teacher and students." Our research takes it thus as axiomatic that the more educators know about students as people the better educators will be able to teach people as students in their classrooms. Among others, Fenstermacher (1979), Hawkins and Pea (1987), Lythcott (1991), and Shymansky and Kyle (1992) espoused similar views.

One knows from fields as diverse as theology, cognitive anthropology, and philosophy that a person's thinking is based on a set of first principles, so to speak. This is a worldview according to Cobern (1991) and it is "not merely a philosophical by-product of each culture, like a shadow, but the very skeleton of concrete cognitive assumptions on which the flesh of customary behavior is hung" (Wallace, 1970, p. 143). These assumptions or, more accurately, presuppositions exert a broad influence over one's thinking (although the effect at any one point is likely to be low) (Jones, 1972). One also knows from philosophers such as John Dewey (1976) and Nel Noddings (1993) that all experience for a person is continuous. Yet, as children grow, and certainly as adults, many learn to box off portions of their thought lives so that, for example, scientific and aesthetic knowledge become separately and exclusively boxed. Science educators are well aware of the phenomenon of boxing science as school knowledge. This is a learned behavior that works against the long-term best interests of the person and of the disciplines involved. Thus, if one takes seriously the concept of worldview and the assertion that all experience is continuous, then one can state with considerable assurance that the beliefs and experiences students bring to the classroom influence their learning experiences in the classroom. Moreover, it is not at all clear that teachers recognize connections among ideas and experiences that for any given student are quite important. Therefore, gaining knowledge of what students bring to the classroom can lead to insight into how learning environments can be more effectively designed. At this point, our research sought to supply some of this descriptive data. Clearly, however, information could come from anywhere and, as Postman (1985) is wont to say about modern culture, one could easily drown in a sea of irrelevance. To avoid this, our research was grounded in a logico-structural theory of worldview (Kearney, 1984; Cobern, 1991) which provided direction as to what research questions to ask.

Worldview research in science education dates at least to Kilbourn (1984) and Proper, Wideen, and Ivany (1988). Cobern (1991) borrowed a logico-structural model of worldview from anthropologist Kearney (1984) in an attempt to bring greater coherence and sophistication to worldview research in science education. Briefly stated, the logico-structural model is a set of seven fundamental and universally found categories: self, nonself (or the other), classification, relationship, causality, time, and space. These categories offer a useful way of examining people's understanding of the world in which they live. They say nothing about the content of this understanding, however. For example, in American culture, many will address the description of self by asking, "Who am *I*?" In Japanese culture, the description of self is much more likely to raise the question, "Who are *we*?" (Kawasaki, personal communication). Worldview theoretical work was extended in Cobern (1993b, 1996; also see Baker, 1997; Lewis, 1998) and applied to empirical work in Cobern (1993a), Lassiter (1993), Lawrenz and Gray (1995), Lee (in press), Lewis (1996), and Ogunniyi, Jegede, Ogawa, Yandila, and Oladele (1995). Allen (1998) and Lynch and Jones (1995) did related work. Following Redfield's (1952) work in anthropology, the category of nonself—that which is not one's self—can be roughly described by three subcategories: the natural world, the social world, and the spiritual world. The research reported in this article is about the subcategory Nature, or the natural world.

Views of Nature

Sperry (1983, p. 114) suggested that Nature is "a tremendously complex concept that includes all the immutable and emergent forces of cosmic causation that control everything from high-energy subnuclear particles to galaxies, not forgetting the causal properties that govern brain function and behavior at individual, interpersonal, and social levels." This definition has a rather reductionist flavor characteristic of modern, Western culture. The Western view of Nature is characteristically mechanistic. It is an inorganic view of the world as a "great machine, which, once it has been set in motion, by virtue of its construction performs the work for which it was called into existence" (Dijksterhuis, 1986, p. 495; also see Stillman, 1977). This mechanicism which dates to Newton posits the whole as a simple sum of its parts. Causal relations are linearly conceived and context independent. Key elements in this view are the "regularity, permanence and predictability of the universe" (Kearney, 1971, p. 24). With all due respect to quantum mechanics, mechanicism is orthodoxy and remains a pervasive view in Western culture. Foster (1935, 1936), Glacken (1967), Lewis (1960/1994), Merchant (1989), Simon (1970), and Thomas (1983) all contributed significantly to the literature on Nature in Western thought.

True to their Western heritage, Americans frequently view Nature as an object for 'mastery" (White, 1967; Young, 1974). In other cultures, Nature is more likely to be valued for its beauty, if not actually held in reverence (Foster, 1991; Kawasaki, 1990, 1996; Nakamura, 1980). These worldview differences have consequences. Watanabe noted that despite the frequency of earthquakes in Japan, it was only after contact with Westerners that the Japanese began the scientific study of earthquakes. According to Watanabe, "this can be explained largely by [the Japanese] attitude of coexisting with Nature" (1974, p. 281). American feminist literature records a similar attitude, but with different effect. The Western feminist presuppositions under girding the self–nonself relationship are characterized by "interrelatedness and interconnectedness, wholeness and one-ness, inseparability of observer and observed, transcendence of the either–or dichotomy, dynamic and organic processes" (Perreault, 1979, p. 4), not unlike Watanabe's description of the Japanese view of Nature. Many researchers now argue that the gap between women's ways of knowing and the traditional culture of science and science education alienates many women students (Barr & Birke, 1994). Moreover, rather then interpreting this gap as a deficit among women, feminist scholarship such as Evelyn Fox Keller's seminal biography of Barbara McClintock, *A feeling for the organism,* has helped to strengthen the feminist contention that good science does not necessarily require the traditional Western view of Nature.

The traditional Western theme of dominance raises concerns about reckless individualism and the wanton exploitation of Nature. The Indian philosopher Radhakrishnan (1967, p. 145) commented that "the modern mechanistic societies lack the vision of self in man. They recognize only an external mechanistic universe reflected in the machines that man has devised. This is how disintegration becomes the key image of the modern world." In the United States, a small but growing group of people have adopted a radicalized Eastern view of the relationship between self and nonself. As a result, organizations such as the Animal Liberation Front and Earth First! actively seek the end of not only all animal experimentation in science, but meat, leather, and wool industries as well (Foote, 1992; *Los Angeles Times,* 1989, p. A6; *The World & I,* 1995, vol. 10, no. 4: 356–383). The radical activists demonstrate how serious worldview differences can be. That the differences can lead to antiscientific views has not gone unnoticed among some scientists. Holton (1993), Levitt and Gross (1994), Theocharis and Psimopoules (1987), and others all have sounded urgent warnings.

The science classroom should not be exempted from this discussion on Nature. From a worldview perspective, one must ask: What is the image of Nature projected in the science classroom? What is Nature like according to science instruction? Kilbourn (1984), Proper, Wideen, and Ivany (1988), Smolicz and Nunan (1975), Whatley (1989), Wilson (1981), and Woolnough (1989) all suggested that mechanicism is prevalent in Western science education. Is it wise for educators to assume that students will easily accept a mechanistic view of Nature as both appropriate and important when the literature indicates that there are many views of Nature? Indeed, the criticism of modern Western scientific views of Nature (e.g., Merchant, 1989) provides reason to investigate the views fostered in a science class. This line of thought suggests a broad agenda for cultural studies research in science education, premised on the assertion that all ideas, including scientific ones, are expressed within a cultural setting (Geertz , 1973). Thus, one must ask how the cultural setting of the science teacher and curriculum compares with student cultural settings. As part of that agenda, the research reported in this article addresses the students' cultural setting: How do students understand Nature? What concepts have scope and power in their thinking? Where does science fit into their thoughts about Nature? How is science interpreted when it has become an integral part of student thinking about Nature?

These questions, moreover, suggest an alternative view of scientific literacy and literacy assessment. The elimination of scientific illiteracy is the principal and historic objective of science education at the school level. Scientific illiteracy is typically defined as a *cognitive deficit,* to use Layton's (n.d.) and Jenkins' (1992) description, assessed by quantitative measures involving both science concepts and processes. The National Assessment of Educational Progress (NAEP) (1979) and Miller (1987) assessment series in the United States are good examples of this approach. Layton, Jenkins, MacGill, and Davey (1993) identified three weaknesses with this approach. The first is simply that literacy assessments involve a limited number of scientific concepts and it may well be that people taking the assessments know other things about science which are not on the assessment. Second, laypeople (in contrast to scientists and science educators) may have different interests, and so the concepts used in the assessments are a mismatch with lay interests. Third, laypeople may have a different purpose for understanding science. The literacy assessments are based on a scientist's view of the natural world. In the public, the purpose for understanding science may have more to do with "'scientific savvy'. . . the practical 'street wisdom' which a citizen needs to cope effectively in an advanced industrial democracy" (Layton et al., 1993, p. 13). With these objections in mind, the acid test of whether science has influenced the way a person thinks is not a set of explicit questions about science, such as asking for an explanation of a particular science concept or the construction of an experiment to test a scientific hypothesis. Rather, it is whether science has become an authentic part of a person's everyday thinking.

The research reported here asked to what extent students enjoin scientific knowledge vis-à-vis other domains of knowledge in a discussion about Nature, given that science is unarguably relevant to the topic of Nature, and yet Nature is a topic that most people do not explicitly associate with science. Moreover, what are the concepts that appear to have scope and force in the students' thinking about this topic? It is one thing to be able to give correct answers on a science exam; it is quite another to use scientific knowledge appropriately in the absence of any kind of science prompt or cue. As noted by Heller and Finley (1992, p. 259), it is "important to understand *when* and *how* students apply their knowledge" (also see Heath & McLaughlin, 1994). Thus, we intended our research to represent accurately the typical thoughts that students in our study had about Nature. We recognized that as these students learned and matured, their ideas would change and develop. We sought to illuminate some of the various ways in which students think about Nature without judging even the most unorthodox perspectives. Our position was that scientific literacy can be developed from a number of different perspectives on Nature—only one of which is the rather narrow perspective of typical school science curricula—and for that to happen in science education, there needs to be an increased appraisal of the knowledge and values brought to the science classroom from other domains.

An Interpretive Methodology

The research objective of our methodology was to map the qualitatively different conceptualizations of Nature[1] held by people, or what might be called *terrain of belief* regarding Nature (also see Jones, 1972; Marton, 1988), and thus to better understand conceptualizations of Nature and the place science finds in those conceptualizations. The concept of Nature, however, is quite profound and not easily addressed extemporaneously. Thus, for most persons, one cannot simply ask, "What is Nature?" and expect to learn much. One could ask a series of questions, but questions inevitably suggest certain types of answers to the exclusion of others. Instead, in our methodology, data were gathered via semistructured interviews that involved elicitation devices (Bliss & Ogborn, 1987; Fetterman, 1989) designed to encourage a person to talk at length about Nature, to think aloud about Nature. So as not to lead the interview, the elicitation devices were multidirectional prompts—that is, each device prompted in many directions at one time. It was up to the informant to decide which of the many directions to take. At no time did an interviewer introduce science (or any other specific domain of knowledge) in the conversation. It was solely up to the informant to bring science or any other topic to the discussion. Although we used no single specific set of questions in the interviews, the following questions served as a tacit guide for questioning during an interview:

1. Can one *know* things about Nature?
2. If so, what *sorts of things* can one know about Nature and *how* do these things become known?
3. *Who* finds out these things that can be known about Nature?
4. *Why* do they (or does anyone) seek to know such things about Nature?

These heuristic questions were important for uncovering scientific ideas without directly asking about science. The interviewer, consistent with Spradley (1979) and Kvale (1983), was there to ask probing questions and encourage the informant to speak freely and at length.

The analysis of data began with transcribing and coding the interview audiotapes. Transcript segments were then printed by code word and collated, and the segments became the basis for a concept map. The concept map provided a graphic organizer for the interview by showing both specific ideas discussed by an informant and where an informant related two or more ideas. Subsequently the concept map became the outline on which a first-person interpretive narrative was constructed. The first-person interpretive narratives were composed almost exclusively from the language of the informants, with the informants' emphases, and showing the conceptual relationships specifically mentioned by the informants.[2] Once constructed, a concept map and narrative were shown to the informant for review and comment. After discussion with the informant, the researchers constructed the final versions incorporating the informant's editing. No narrative was used without the informant's full affirmation of accuracy.

Throughout the research process, from interviewing to coding to concept map and narrative production, the researchers were alert for possible assertions that could describe salient features of the data. In this study 37 tentative assertions were eventually developed. These were reduced to seven final assertions (see Cobern, Gibson, & Underwood, 1995a), four of which are reported here. The final step in our methodology was to have the assertions and arguments externally validated by three qualitative researchers not involved with the study. These validators cross-checked the assertions, supporting arguments, and examples against the transcripts, case concept maps, and narratives. The specifics of the methodology and analysis techniques are described elsewhere (Cobern, 1993a; also see Cobern, Gibson & Underwood, 1995c).

The Students

The research was a descriptive case study, as described by Stake (1988), of 16 ninth graders from a semirural high school in the central desert region of Arizona. The two science researcher/teachers (Flake et al., 1995; Wong, 1995) who participated in the research asked for student volunteers. From these volunteers, students were chosen so that there was a balance by sex and science grade success. The students who participated in the research were as a group typical of students found in this high school's ninth-grade science courses. Each researcher/teacher subsequently worked with eight students. (We noted that in a previous study on the same topic, 15 cases had been sufficient to achieve code redundancy during the analysis of interview transcripts) (Cobern, 1993a.) The students were from middle- to upper-middle-income homes. The high school is located in an area many families choose because it combines proximity to a large city with a rural desert atmosphere. It is also somewhat of an artistic community that values the natural beauty of the Arizona desert.

Presentation of Assertions

Assertion 1. The ninth-grade students in this study tended to discuss the natural world using concepts from religion, aesthetics, science, and conservationism. A breadth of perspectives, which only sometimes were connected, typically characterized student discussion. A few of the ninth graders demonstrated through their concept of Nature a strong interest in science and voiced specific views about the nature of science. Visible homogeneity among the students (e.g., a classroom of middle-class Anglo students) actually masked substantial variation of thought with regard to Nature, science, and science related concepts.

This assertion is about diversity. Consider the following excerpt from one of the female students.

> Patricia: God created the natural world. It has many characteristics: it's powerful, diverse, changeable, and beautiful . . . physically and emotionally. The Bible says God created the heavens and Earth, so I think that explains to me what Nature is. . . . The wonderment of the world increases knowledge through science, but is limited, due to its complexity . . . it can also be beautiful in a naturalistic way. . . . Both views, scientific and religious, try to explain the hard questions, such as the origins of life; in which I believe there is no true answer. Science and religion have distinct roles in our life's teachings. Science teaches us how to conserve our resources, and how to possibly restore them, while religion teaches us the caring attitudes required to be productive members of the natural world. . . . People must learn to take the time to enjoy the beauty of Nature, both religiously and scientifically. (SAU.n2, Narrative)

Glancing at her narrative, one quickly sees religious, aesthetic, and conservationist elements in addition to science elements. Bruce's narrative excerpted below also shows diversity of thought.

> Nature is complex, but it is orderly and knowable within a 20% or so margin of error. Some things are dependable but not always good, like there will always be earthquakes, rain, volcanoes, etc. Most of the natural world can be known through science and the theories that have been developed by science. . . . Our knowledge is limited by hard questions, such as why does the Earth spin the way it does, what is gravity, and why our planet is solid and not gassy. This mystery and the knowledge we have lead us to a sort of philosophical sort of beauty. Having an open mind allows you to see the beautiful things in Nature, like life in the Sahara Desert. Some people think it is ugly and is a wasteland, but if you think about it, it has an abundant amount of life, which makes it beautiful. It is beautiful in different ways. There is the physical beauty, and there is the emotional or "amazing" beauty. . . . Some things scientists know about are: weather patterns, El Niño, ozone depletion, and tectonic plate movements. . . . The natural world is exploited because of us humans. The earth is in danger because humans are destroying the ozone layer, rain forests and precious land. An incredible thing is that our resources are being exploited and used up, and we need these things to continue our life on this planet. As humans, we have personal and religious obligations to our world to take care of it. (SAU.n4, Narrative)

Bruce's ideas about Nature combined ideas about resources, conservation, aesthetics, complexity and order, and scientific knowledge. He differed with Patricia in that he had much more to say about science and much less to say about religion. Also, his view of aesthetics was an intellectual view.

Patricia and Bruce each had a varied but coherent view of Nature in that they tied ideas together. The following excerpt from Holly provides a different example of a diverse conceptualization of Nature.

> The natural world is just there, you know, fish, bugs, dirt, animals, and plants. There are aspects of Nature that have purpose because it was probably created by God, but I am not really religious so I can't explain it. It is very big and complex, like the ocean, which makes it somewhat confusing to know about. There is some order in Nature, but not much. . . . Cities are not included in the natural world because they are built by unnatural means. Because of these cities, the natural world is exploited; like our resources that we use for medicines, paper, and breathing. People need to realize that our resources need to be protected because they are necessities for life. They can be recycled. I do not recycle because it is probably not in danger now or during my lifetime, so what's the point? (SAU.n7, Narrative)

Patricia and Bruce showed thoughtfulness about Nature and some sophistication in marked contrast to Holly. Holly appeared to have no interest in science, religion, or aesthetics. Her ideas appeared disconnected and she seemed neither interested in nor concerned about Nature in general.

Among the other students, still more variations and similarities appeared. Kevin, Alice, and Howard, like Bruce and Patricia, also showed a strong interest in science as they talked about Nature, but in each case emphasis varied, as seen in the following two narrative excerpts.

> Kevin: I think Nature is very complex. There are unknown parts of Nature and they are confusing to me because there are no real laws controlling them. There is no order. . . . I think that because Nature is so important to us, we need to work to learn more about it. Knowing about Nature makes us feel more at home in it. . . . There are also knowable parts of Nature. We can learn about Nature through science. There is order to some things and we can base predictions on that. . . . I want to be a scientist. Science raises many questions about Nature. By trying to answer those questions, maybe we can learn to restore some of the changed, damaged parts of Nature. Our environment needs protection for the future. We need to protect the environment by recycling, car pooling, reducing pollution, conserving trees, etc. The ability to protect requires knowledge. (ATG.n7, Narrative)

> Alice: I want to be a scientist. Nature is very important to the world of science. Through science, we understand many of the patterns in Nature; food webs, weather patterns, how the solar system works, etc. We need to know more about Nature and we keep studying it to find out how things work and to discover ways that different things affect each other. However . . . it is all people in the world that must act responsibly to help solve the problems we've created in Nature. (ATG.n1, Narrative)

Alice and Kevin explicitly said they wanted to be scientists and emphasized the importance of knowledge. Both talked about environmental issues and using science to promote environmental objectives. In addition, Alice talked about patterns in Nature. In contrast, Kevin said, "Nature is very complex. . . . There is no order" in Nature. Kevin, unlike Patricia and Alice, did not raise religious issues with regard to Nature, but he did talk about the aesthetics of Nature. Alice spoke about religion, but unlike Patricia, Alice indicated that she had accommodated religion to science.

> While I am a Christian I also believe that science has proved wrong many of the things in the Bible. Yet, I do think that there is a purpose for our existence, and God is behind

> it. Science can explain how things work but there are many "why" questions that science doesn't answer. (ATG.n1, Narrative)

Howard provided yet another variation on student perspectives supportive of science. In the excerpt below, one hears the student who had the most to say about science and with the greatest enthusiasm.

> I think that Nature can be fully known because it is logical . . . as time goes on, we will understand more and more. Most things about Nature are somewhat orderly or have a pattern to them. Because of this, the study of science allows us to explain what is going on in Nature. . . . The orderliness also lets us predict many things that are going to happen . . . Nature is very powerful and sometimes it seems chaotic, but that is mostly because our knowledge is incomplete and therefore our understanding is limited. . . . I think that everything can be explained by science. . . . Nature provides us with many resources. Energy, shelter, food, and water all come from Nature. Scientific studies will allow us to use more of Nature to our advantage. Our exploitation has caused pollution. . . . We are also able to restore it somewhat by conservation efforts. We need to be careful, though, of environmental extremism. (ATG.n3, Narrative)

Howard showed a strong inclination toward a scientific, utilitarian view of Nature. He referred only weakly to environmental concerns, and he was the one student to suggest that environmental concerns can be taken too far. Howard made no reference to aesthetic or religious aspects of Nature. Rather, he appeared to focus on Nature as logical and orderly and fully amenable to scientific explication. Taken together, Howard, Patricia, Bruce, Alice, and Kevin are five students who showed an interest in science and whose understanding of Nature involved science—yet how very different their perspective really are.

Not all students in the student spoke supportively of science. Indeed, other students in our study were very much less sanguine about science. Consider the following excerpt from Art.

> Nature is a source of knowledge. . . . At the present time, our knowledge of the natural world is limited. Many things that we perceive to be complex and confusing because we don't understand them are actually quite simple and orderly. The construction of a spider web, for example, is quite a complicated operation to us, but to the spider building the web it is a simple procedure. . . . It is more important to have a spiritual understanding of Nature than just scientific knowledge. That understanding can't be gained from school. You have to spend time in Nature and learn to feel it. Than you will understand it. The American Indian culture has the kind of understanding for Nature that encourages preservation rather than destruction. . . . Unfortunately, scientists and scientific knowledge are also increasing our tendency to pollute, destroy, and clutter up the earth and space. They are trying to destroy it and study it at the same time. (ATG.n4, Narrative)

Art is a mystical environmentalist, Howard's opposition. As with Howard, we found Art to be both thoughtful and articulate, but his views on Nature and science could not be more different from Howard's. Howard asserted that "Nature can be fully known because it is logical." Art asserted that one must "learn to feel" nature. For Howard, Nature seemed only to be a resource for human physical needs. For Art, Nature was also a mental and spiritual resource. Both spoke of Nature as understandable, but that is where the similarity ended. Howard was convinced that science will eventually explain all of Nature. In contrast, Art was much more impressed with the knowledge of Nature one achieves by personal experiences with Nature and the type of knowledge traditionally held by Native Americans. Art was as much opposed to science as Howard was supportive.

Assertion 2. After 9 years of schooling, the level of science integration within everyday thinking remained low among these ninth graders. In their discussions of Nature, most volunteered little school knowledge of science. They were aware of school science topics such as the ozone layer, rain forests, and the Big Bang theory. Such topics were voluntarily mentioned, but usually without elaboration even when asked. The ninth graders made few references to general concepts of order or pattern in Nature. Moreover, some students showed signs of a negative perspective of science, while others seemed barely to know science existed.

What should students leaving the K–8 grades know about science? This is not an easy question to answer, and our intention was not to pass judgment on these students or their science education experience as elementary students. The intent was to provoke discussion about expectations for elementary school science by showing how this group of students talked about science and Nature. Howard and Bruce exemplified the student for whom science is very important. Most of the students in this study had much less to say about science in regard to Nature. Holly's most specific comment was that "the natural world is just there, you know, fish, bugs, dirt, animals, and plants" (SAU.n7, Narrative). Similarly, Jackie simply offered that "Nature. . . is everything around us, like plants and animals... These resources are essential for life and . . . using them leads to pollution that is destroying our ozone layer" (SAU.n3, Narrative). Even though prompted during the interview, Jackie offered no explanation or examples to go with her statement. She offered nothing further about plants and animals. She named no specific resources nor did she offer an account of how these resources are essential. Jackie offered no specific examples of pollutants, although she did mention ozone destruction.

Betty had somewhat more to say. She seemed to have a more developed sense of what science is and how it works. As seen in this excerpt, science is logical, factual, and problem solving.

> Betty: Nature is knowable . . . people know Nature on a scientific or factual basis. Their knowledge is based on facts and can be applied to solving problems as it is logical. There is an order to Nature which we can use to predict some things—weather, for example. Ideas about evolution, the ice age, extinction, and global warning can be developed and studied with scientific methods and proofs. Medical cures are another benefit we've gained through factual knowledge. (ATG.n8, Narrative)

In contrast to Howard, Betty's statements were relatively simple, and though she listed several science concepts, she did not elaborate on them. She did, however, associate an orderliness with Nature that allows a certain amount of prediction, and linked order in Nature and with science. This is of interest, since "order in Nature" is an important elementary school science objective [American Association for the Advancement of Science (AAAS), 1993]. Listening further, one finds that overall, Betty has an ambiguous view of Nature and science.

> But people know or understand Nature in two very different ways. Some understand Nature on a religious or spiritual level. They "know" Nature as an emotionally uplifting experience. God and Nature are intermingled in New Age spirituality. Nature has aspects that can be considered not only to be living and but to also have consciousness. . . . My understanding of Nature is more scientific and logical than spiritual, but there are some aspects of both attitudes in my thinking. Nature is complex and therefore mysterious. It is also powerful. There are many questions that are still unanswered. We don't understand a lot of things in Nature because of its unpredictability. Tornadoes and earthquakes are unpredictable and powerful. Nature is also mysterious because it is living. Things in Nature have a consciousness. Since we are part of Nature and we have feelings, then Nature has

> feelings. Things in Nature have feelings. Plants, for example, scream when you pick a flower. That is something people don't realize or understand. The consciousness and the beauty of Nature are another type of powerful force. (ATG.n8 Narrative)

Although Betty began with orthodox comments about order in Nature and scientific understanding, she ended with startling comments from New Age mysticism, which she acknowledged was an influence in her home. Betty's heterodox views on science, order, and Nature lie in marked contrast to Bruce and Howard. Recall that for Bruce, "Nature is complex, but it is orderly and knowable within a 20% or so margin of error" (SAU.n4, Narrative), and for Howard, "Most things about Nature are somewhat orderly or have a pattern to them. . . . The orderliness lets us predict many things that are going to happen" (ATG.n3 Narrative). These comments are consistent with an orthodox science curriculum. The AAAS noted that "Science presumes that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study" (1990, p. 2). Howard is explicit about order in Nature. Betty's view of order in Nature is ambiguous at best. Art's view of order is basically a spiritual view. Other students alluded to order in Nature, but not as an important attribute of Nature or as a concept fundamental to science.

Four of the students actually seemed much more impressed by disorder in Nature. Jackie commented that "The natural world is incredibly mysterious. There is really no order to what happens. The main mystery is how life came about on this planet" (SAU.n3, Narrative). Consider the following excerpt:

> Simon: I don't really understand a lot of things. I suspect that much of Nature isn't meant to be understood. Because Nature lacks order and is often unpredictable, it is often unexplainable. Animals also do things that we don't understand and can't explain. (ATG.n2, Narrative)

Simon was one of three students in this study who never mentioned the word *science*. Holly was another. Holly spoke of some order in Nature, but also said Nature was "complex" and "confusing." Allen was the third student not to mention science; nor did he speak of any order in Nature. The closest he came to a scientific statement was, "Nature is knowable to some extent; like people can recycle and fix the ozone layer by not driving cars and stuff" (SAU.n6 Narrative). He then added, "But most of [Nature] is not knowable. . . . For the most part, Nature is not orderly and predictable in the sense that nothing stays the same" (SAU.n6, Narrative). For Allen, what seems predictable about nature is that Nature will be better off if people are less intrusive.

As detached from science as Simon, Jackie, Allen, and Holly appeared to be, they were not negative sentiment about science. Such was not the case with Art and Paula, as seen in the following excerpt.

> Paula: Nature is mysterious. I wonder about Nature. . . . God created the natural world, which makes it very mysterious and, for the most part, unexplainable. . . . Because the earth is God's, humans have no right to mess with it. . . . With the exception of hippies and white witches, who value spiritual ideals, the emotional values, and the mystery of Nature, man has "doomed" the planet. I don't understand the human world and why people feel the need to study Nature. Studying Nature only causes trouble. . . . It is a very spiritual world if man's technology would not interfere with it. (SAU.n1 Narrative)

Paula's narrative shows a strong sense of the mystery of Nature and spiritual values concerning Nature—and "humans have no right to mess with it."

Assertion 3. Science grade success is not correlated with the concepts these ninth graders typically chose to use in a discussion about Nature. Students with the most science grade success[3] *did not necessarily grasp fundamental concepts about Nature and science such as the concepts of order and pattern, nor did they necessarily demonstrate a scientifically informed view of Nature. Science grade success does not appear to mean that a student will understand that science is about Nature, nor does having an understanding of Nature appear to influence school science grades.*

Students such as Bruce and Howard perceived order in Nature and that scientific knowledge is to some extent predicated upon order. They have the appearance of Costa's (1995, p. 316) potential scientists with "A" grades. As it happens, Bruce and Howard were B-minus science students. Betty, with her much more ambiguous stance toward order in Nature and scientific knowledge, was also a B-minus student. Of the three other students (Patricia, Kevin, and Alice) who by their language showed an interest in science, two were A students and one was a B student. Less surprisingly, Allen and Holly, who saw little order in Nature and had nothing to say about science, were C students. In terms of science grade success, however, there was not much difference between Bruce, Howard, Holly, and Allen, even though their remarks showed substantial variation.

More surprising were the A science students, Patricia, Sally, Liz, Ann, and Kevin. During the interviews, each said something positive about science, but none chose to speak of Nature as having order or spoke in terms of what (say) the AAAS would consider a scientific worldview. Kevin came close, noting that "there is order to some things and we can base predictions on that. Examples of knowable, predictable things would be states of matter, life cycles, the earth's plates, and sometimes the weather" (ATG.n7 Narrative). However, he also noted that "Nature is very complex. There are unknown parts of Nature and they are confusing to me because there are no real laws controlling them. There is no order" (ATG.n7 Narrative). Indeed, Kevin's interest in science had little to do with the traditional notion of fathoming the depths of Nature through science, and everything to do with his environmentalist perspective, as seen in this excerpt:

> The resources in our environment are a necessity to us for our survival. But our growing need has led to exploitation due to people's lack of caring. . . . I want to be a scientist. Science raises many questions about Nature. By trying to answer those questions, maybe we can learn to restore some of the changed, damaged parts of Nature. . . . We need to protect the environment. . . The ability to protect requires knowledge. (ATG.n7, Narrative)

Similarly, Ann noted that some events in Nature are predictable, but that Nature can also be confusing: "Nature is knowable, but the questions I ask about Nature make me think that Nature is sometimes very confusing. It is also changeable" (ATG.n6, Narrative).

According to Sally:

> The natural world is somewhat knowable through science and religion. It is too big to be entirely explained. . . . Science and scientists help us to know some of the natural world because things can be predicted, like animal behavior . . . but we will never really know why things work. Why is Nature here? What is the purpose? How did life form? Science can teach us how to be better conservationists through research and technology so we can avoid pollution which ruins Nature. (SAU.n5, Narrative)

Liz commented that:

> The natural world is knowable by means of education through science and by learning through personal experiences. Eventually, we will probably be able to know most things

> about the natural world. However, some things will be kept a mystery because not all things are meant to be known. Science tends to teach the how and what questions about the natural world and religion hints at the why questions somewhat. Before it can be knowable to someone, that person must care about the natural world. Lack of care not only hinders your personal thought, it sometimes leads to exploitation of natural resources and natural environments like the rain forests. (SAU.n8, Narrative)

For Sally, religious knowledge set an upper boundary on scientific knowledge. Similar influences from religious knowledge are evident in many of these student remarks yielding an unorthodox scientific perspective (that is, unorthodox from the perspective of traditional science curricula). What was generally missing in the remarks from the A students was the conviction of an underlying order in Nature that makes science possible. Einstein's thought that the only thing incomprehensible about Nature is that it is comprehensible is not evident here—not that this kept these students from appreciating science or getting good science grades. Rather, this lack of conviction on a presupposition many scientists see as fundamental is an indication that at this point in their lives, their school science success, their conception of scientific knowledge, and their conception of the natural world did not rest on the Western tradition of Nature as an orderly system. This group of students was much more likely to be interested in science for environmental reasons.

Assertion 4. Regardless of school science grade success, most of the ninth graders attached considerable importance to personal experiences with Nature. Their environmental inclinations were strong.

Most of the student narratives show emotionally buoyant responses to Nature that cannot easily be associated with anything related to school. These responses were more personal. The following comments are typical.

> Simon: I really enjoy being out in Nature. It gives me good feelings. I like walking around, climbing mountains, watching a deer drink out of a river, and things like that. I think about Nature and you could say I'm in touch with Nature. (ATG.n2 Narrative)

> Howard: I find Nature to be peaceful when I'm hiking up a mountain or something like that. But I also find it peaceful when I'm just walking around at night sometimes. (ATG.n3 Narrative)

> Samantha: The pleasure I get from being in Nature is very important to me. I spend a lot of time in Nature. I'd be pretty bored if I didn't have it. (ATG.n5 Narrative)

> Ann: I like to go where you can't see any influence by man. When I'm out in Nature I feel calm and peaceful. . . . Sometimes when I'm out in Nature and I have time to think . . . (ATG.n6 Narrative)

> Kevin: I live in a "natural" area. Being in Nature is important to me. I can see and feel it so I know it exists. I enjoy the beauties of Nature, the animals, mountains, etc. It supports my sense of self. (ATG.n7 Narrative)

> Sally: Sometimes it is nice to go somewhere humans have never been. For example, I like going to a totally natural place like a grassy tree area where I can read and just ponder things. It would be really neat to go in a capsule under the ocean and just be absorbed by the beauty. I guess my mom instilled this value of beauty in me. (SAU.n5 Narrative)

> Liz: I live out in the desert where I can enjoy looking and thinking about the animals that live there. I get peace from that. (SAU.n8 Narrative)

Of the group of students, only Holly—the student who displayed indifference—had nothing emotional to say about Nature. Of the students who through their remarks showed themselves to be more science oriented, only one described his aesthetic sense of Nature in intellectual terms that could be associated with science. Although aesthetic remarks and personal experiences were sometimes associated with religious and environmental views, they were not typically associated with either school or science.

Putting Things Together: A Discussion

As science educators, we wish to learn something about the extent to which ninth graders will voluntarily enjoin scientific ideas (vis-à-vis other types of ideas) in a conversation only tacitly related to science. In this study, the findings were findings of diversity. Underneath the facade of demographic homogeneity, we found considerable conceptual diversity. Given the chance to talk freely about Nature, these students talked about many ideas. In contrast, other research with the same method showed that science professors and science teachers almost immediately lapse into science talk (Cobern, 1992, 1996). It is instructive to compare the diverse set of student ideas with an excerpt from a high school science teacher's narrative. Mr. Hess was one of the science teachers for the students in this study.

> Nature is orderly and understandable. The tides and the rotation of the earth . . . That the planets and the stars are governed by physical forces and any deviations are simply because we have not yet discovered the other part of Nature's orderliness. . . . As a science teacher, I feel that with enough scientific knowledge all things are understandable. I think that the more we understand about matter itself, and the more we know about how to make things, the more predictable Nature will be. Scientific or reductionistic thinking is very powerful. I feel that once we know enough about the minutia of the world, breaking it down by using the scientific method, scientists tearing it apart and analyzing the parts of Nature and seeing how they interact, that we will be able to predict just about anything about Nature. (WWC.n3, Narrative)

Mr. Hess offers a modernist view of science (Burtt, 1967) that strongly emphasizes reductionism. His viewpoint is reminiscent of Crick's Astonishing Hypothesis: "'You,' your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules (Crick, 1994, p. 3). Some have criticized this reductionist perspective as the "mythology of school science" (Smolic & Nunan, 1975), while for others it is "a candle in the dark" (Sagan, 1995). However one judges this modernist perspective on science or the reductionist nature of many traditional science curricula, it is clear that most of the ninth graders in the current study have a much different perspective. Unlike the science teacher, Mr. Hess, the students were not of their own accord focused on science. Howard was the one exception. For other students, Nature was conceptualized as a composite of a number of different perspectives: aesthetic, religious, conservationist, and sometimes scientific.

For two students, the variation was extreme. Art held remarkably premodern ideas for being a middle-class, Anglo American student. He spoke of being much influenced by Native American thought, and his account of Nature is reminiscent of an Australian Aboriginal view expressed by David Mowaljarlai.

> You have a feeling in your heart that you're going to feed your body this day, get more knowledge. You are looking at Nature and giving it your full attention. Seeing all its beau-

> ty. Your vision has opened and you start learning now. . . . When you touch them, all things talk to you, give you their story. It makes you really surprised. . . . You feel you want to get deeper, so you start moving around and stamp your feet—to come closer and recognize what you are seeing. (Mowaljarlai & Malnic, 1993, p. 53)

The other student, Betty, spoke of Nature in explicit anthropomorphic terms:

> Things in Nature have a consciousness. Since we are part of Nature and we have feelings, then Nature has feelings. Things in Nature have feelings. Plants, for example, scream when you pick a flower. That is something people don't realize or understand. The consciousness and the beauty of Nature are another type of powerful force. (ATG.n8 Narrative)

Again, there is a striking parallel with traditional non-Western thought. Consider the following comment of a Rock Cree individual of sub-Arctic, Canada.

> Really [animals] resemble human beings, they differ only a little. They talk and eat and live like human beings. But you can only know this if you dream of them. It is excessively difficult to know these things. The animal doesn't want us to see it. Maybe we see a "small piece" of animals only. Only a "small piece" is what they show the people. (Brightman, 1993, p. 168)

Similar views concerning both plant and animal life can be found in Native American culture (e.g., Burbank, 1993), but such views are not what many would expect to find among the middle-class Anglo students in this research. Moreover, such views certainly do not represent canonical science, but represent a very different view of Nature and order within Nature. Thus, the contrast between Howard and Mr. Hess, the scientific materialists, and Art and Betty, the environmental mystics, could hardly be more striking. By current curriculum standards, there is no question as to which students are the more scientifically inclined.

Border Crossing

What does it mean to be scientifically inclined? Project 2061 (AAAS, 1993) presents a standard description of the notion of a scientific worldview that emphasizes a rational, objective, material, utilitarian, and technical perspective on Nature. We suspect that the authors would claim that leaving out other perspectives should not be taken as a slight, but as the result of the proper demarcation of science vis-à-vis other domains of knowledge. That could be true. It also could be true that, like the views of Mr. Hess, these are the terms that best describe the authors' primary vision of what the world is like, and they are oblivious to other terms. Either way, students are left to make their own accommodations with science. This was what Costa's (1995) study found about students enrolled in high school science. She characterized student attempts at accommodation as "border-crossing" efforts and described several categories (also see Aikenhead, 1996; Cobern & Aikenhead, 1998). "Potential scientists" cross borders into school science so smoothly and naturally that the borders appear invisible. Howard easily fit this description. "Other smart kids" manage their border crossing so well that few express any sense of science being a foreign subculture. This sounds like Patricia. Costa found that other students are unable to cross this border. These are the "outsiders" who tend to be alienated from school itself, and so border crossing into school science is virtually impossible. This description fits Art in our study, who eventually dropped out of school. We are thus led to the concern that the typical demarcation of science for school curricular purposes is far from benign, but inadvertently places hindrances in the path of students (such as Art and Betty) who we think really could become potential scientists if given a proper chance.

Inadvertent hindrances to learning in the science classroom raise a question about what interactions can be better understood by explaining the interactions in terms of teacher/student conceptualizations of Nature, if indeed any. The suggestion here is that conflicts between student and teacher conceptualizations of Nature will have an adverse affect on the student's experience in the science classroom. For example, one might ask how well an aesthetically minded person would fare in Mr. Hess's science class. This is a question about cultural border crossings, and the importance of this type of question is corroborated by Turkle and Papert (1990). They concluded in their study of computer science students that some students, especially women, are discriminated against "not by rules that keep people out but by ways of thinking that make them reluctant to join in" (Turkle & Papert, 1990, p. 132). They found that the university computer culture affirms programming as a "rule-driven system that can be masked in a top-down, divide-and-conquer way" (Turkle & Papert, 1990. p. 136). This approach alienates some women students since they are *bricoleurs*. *Bricoleurs*

> construct theories by arranging and rearranging, by negotiating and renegotiating with a set of well-known. . . . They are not drawn to structured programming; their work at the computer is marked by a desire to play with the elements of the program, to move them around almost as though they were material elements—the words in a sentence, the notes in a musical composition, the elements of a collage. . . . The *bricoleur* resembles the painter who stands back between brushstrokes, looks at the canvas, and only after this contemplation, decides what to do next. (Turkle & Papert, 1990, p. 136)

Turkle and Papert suggested, moreover, that a similar situation obtains in science. We concur and suggest that most of the students in our study are *bricoleurs,* and that this is a potential source of difficulty for them in the traditional science classroom.

The Science/Nature Divorce

Although some students such as Howard had at their command considerable scientific knowledge, the overall low level of science concepts that these ninth graders volunteered is consistent with NAEP assessments of elementary science education achievement (National Research Council, 1996; Rudner, Song, Treacy, & Pike, 1984) and concern expressed in the science education community (Gardner & Cochran, 1993). The low level of science talk is perhaps excusable for the typical ninth grader, especially at the start of the school year, but it is not encouraging when one notes a similar lack of elaboration among many older students such as those in Cobern's (1993a) collegiate nursing study. One could take Rutherford's (1987) point of view that elementary science education should focus on a general understanding of what science is about rather than conceptual specifics. In that sense, one would think that while students might not volunteer many scientific details, their years of exposure to science in the elementary grades would give them a sense that there is an order in Nature at least partially amenable to scientific understanding. That appears not to be the case with this group of ninth graders, thus suggesting that for most of these students, the science they learned in school had little to do with the natural world they know by personal experience. Moreover, we would agree with Charron (1991, p. 686) that "despite consistent instruction to the contrary, most students assigned science a minor role in their lives."

This disjunction between the students' experience of the world and the world as constructed in the science classroom is symptomatic of what Eger (1992, p. 342) called the "double distancing" between science and Nature that too often takes place in the science classroom. It is all the more unfortunate given the importance the majority of these ninth graders attached to personal experience with Nature and their strong aesthetic and environmental views that surely could be used to the advantage of science learning in the science classroom. As previously noted, environmentalism was the source of interest in science for several of the students in this study.

As for grade success at school, we know that it is important in society. The narratives in this study, however, reflected little of the students' actual grade accomplishments. We are reminded of Costa's (1993) description of school science as a rite of passage by which society helps some students make the transition from "school student to scientist or member of the scientific community" (Costa, 1993, p. 654). This description fits Howard and perhaps Bruce, who were most likely to continue in school science. As for the other students, if school science is a rite of passage to the community of science and scientists, they seemed only dimly aware of that. They could just as easily be getting their school grades by playing "Fatima's Rules" (Larson, 1995, p. 8). Larson learned from a high school student, Fatima, "Don't read the book. . . . Ask the teacher for help as soon as you're stuck." The rules worked for getting a good grade, but as another student admitted, "I get an A because I do my work, but as for, like, if you could grade me on how much I know, I'd get an F. . . . I don't understand [chemistry]" (Larson, 1995, p. 12). Nor, we would add, is it likely that this student's school science experiences have had much impact on her everyday thinking about the world in which she lives.

Concluding Remarks

Scientific literacy according to Hurd (1993) requires that students be able to use their knowledge of science independently in the everyday world. To borrow a phrase from Lijnse (1995), science education should thus seek to *scientificalize* a student's world. For the eventual scientific expert, this means that "as expertise is attained, a person restructures his/her knowledge of the domain into a framework that is based on critical dimensions that facilitate the daily use of that knowledge" (Smith, 1992, p. 179). We wonder, however, if the future scientific expert and layperson both start at the same place. It could be that science education facilitates this cognitive restructuring process for all students; or it could also be that science education is a natural selection device that selects for those students already amenable to a certain type of cognitive restructuring, as suggested by West (1996). It was Feynman (1995, p. 99), after all, who remarked, "I had [science] in my blood from the beginning." In our own study, it seems clear that Howard's fondness for science preceded his experiences with formal school science. Though anecdotal, the suggestion here is that science education as now conceived is better at selecting for future scientific experts than it is at promoting public scientific literacy.

We noted our interest in science classroom environmental change rather than a diagnostic-prescriptive approach to improving science teaching that essentially assumes that the environment is nonproblematic. In the interest of promoting public scientific literacy, we suggest that classroom environment is a critical factor and that a critical classroom environmental problem is the radical isolation of school science from other disciplines and everyday thinking in general (Britzman, 1986). The assertions of our research suggest that science education does too little to help students integrate the important concepts of their own worlds with the important concepts of science. The assertions suggest that these students would benefit from a science classroom environment that put to use Dobzhansky's (1968, p. 242) insight that "Knowledge gained from science is as necessary as it is by itself insufficient. It must be supplemented by the insights of poets, artists, mystics, and by religious experience." We have modestly suggested elsewhere how this might be done in the classroom (Cobern, 1995; Cobern et al., 1995b). Martin and Brouwer (1991, 1993) provided an excellent resource on science education for helping students develop a personal science. Flannery (1991) developed the idea of an aesthetic understanding of science, and Poole (1995) handled the difficult issue of religious understandings of science. Science–technology–society innovations (e.g., Cross & Price, 1992; Layton et al., 1993) and cultural studies (e.g., Rowe & Probst, 1995) are explicit attempts to change science curricula so that there is much greater interaction between science and the everyday world of students. What these authors have in common is an interest in promoting a science classroom environment that invites students to bring all of their important ideas to a dialogue with the important ideas of science. This is not a suggestion for a bull session curriculum for the sharing of ignorance, but for what physicist David Bohm (1992, p. 16) called a *dialogue*: "The image this [dialogue] suggests is of a *stream of meaning* flowing among us . . . a flow of meaning in the whole group, out of which will emerge some new understanding. . . . When everybody is sensitive to all the nuances going around, and not merely to what is happening in one's own mind, there forms a meaning which is shared." The assertions of this research suggest to us that just such a classroom dialogue is critical for the construction of scientific meaning within the everyday worlds of future (nonexpert but literate) citizens.

Duckworth argued that "dealing in concepts-qua-nouns is barren — an example where someone can 'have' one of these things, and not be able to do much with it" (Duckworth, 1987, p. 51). We share this opinion, and thus through our research have sought a better understanding of the concepts that have scope and force in students' understandings of Nature. We asked, what science concepts are used in student conceptualizations of Nature, and to what extent are they used? How are scientific ideas related to ideas from other disciplines? What is clear is that ninth-grade students tend to discuss the natural world using several different perspectives — for example, aesthetic, conservationist, religious, and sometimes scientific. The group of ninth graders included some "science types." Other students likely learned their science as concepts-qua-nouns; but in our view, these and other students are not scientifically literate until the conceptual knowledge they have of science is meaningfully integrated into a cognitive framework that includes their everyday thinking. That, however, requires educators to come to know their students as persons. Duckworth (1987) explained:

> Meaning is not given *to* us in our encounters, but it is given *by* us — constructed by us, each in our own way, according to how our understanding is currently organized. As teachers, we need to respect the meaning our students are giving to the events that we share. In the interest of making connections between their understanding and ours, we must adopt an insider's view: seek to understand their sense as well as help them understand ours. (p. 112)

Unfortunately, the insider's view involves perspectives too often ignored in the science classroom. Fourez (1988, p. 269) was once told by a colleague, "My course is scientific, period." Mitman, Mergendoller, Marchman, and Parker (1987, p. 626) reported from their research that "the most striking results [were] that the sample teachers rarely or never went beyond science content in their instruction by trying to relate that content to other domains of scientific literacy and provide a larger context for the understanding of science facts and concepts." Perhaps, then, one should not be surprised by the reception given to a British proposal to place school science within a broader philosophical context. McCarthy (1995, p. 8) observed that science has always "explicitly and inevitably concerned itself with questions of existence, questions about the Nature and purpose of being, the Nature of matter." He was, however, surprised at his colleagues' response to the proposed curriculum revisions—revisions he thought unproblematic (McCarthy, 1995, p. 7): "Not our job . . . nothing to do with us. . . . These questions belong in [religious education], not science." McCarthy (1995, p. 7) asked himself incredulously, "What does this indicate? Since when has science ceased to take an interest in questions of meaning, and purpose, beauty and mystery? Is there some connection between this blinkered worldview and the widely attested loss of interest in science in schools?" We think so. We can easily imagine Art, Betty, and Simon wanting to know what science has to do with the meaning, purpose, beauty, and mystery of Nature. For these students, science education and science must "undergo enrichment and de-formalization, getting cross-connected with the familiar phenomena of everyday life; and the familiar 'common sense' ideas not suppressed or declared wrong, but reconnected and re-constructed (Hawkins, 1992, p. 219). [4]

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Notes

[1] There are idealizations of the concept *Nature* and other uses for the word *nature* as in "human nature." In this study, we take Nature to mean the natural world. "The material world and its phenomena. The forces and processes that produce and control all the phenomena of the material world" (The American heritage dictionary of the English language, 3rd ed., 1992). The research method includes procedures for ensuring that persons being interviewed are aware of this general definition.

[2] We use this circumspect method of narrative development because we find that it provides a more thorough and accurate description of a person's thoughts about Nature than can be got by direct questioning. Our notion of a "first-person interpretive narrative" is unique, however, and not without controversy. Thus, we wish to emphasize two points.

1. Considerable effort is exerted to make sure that the narratives are as consistent with the interview data as possible. Thus, no concepts or words of substance are contributed to the narratives by the researcher. The researchers only fill in with connecting words and prepositions. The researchers assemble various portions of an interview strictly according to topics raised by the person being interviewed.
2. All narratives are member checked and the person interviewed always has editorial and veto power over the form and use of his or her narrative.

The full narratives may be viewed at <http://www.wmich.edu/slcsp/Narratives.html>.

[3] The notion of grade success was suggested by the teacher/researchers in this study, recognizing that grades do not always reflect knowledge and understanding of the course objectives. We simply checked student records to see if their past and present science grades had typically been A's and B's, C's, or less.

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