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Conceptualizations of Nature and Scientific Literacy, Part I: Research Methodology

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Abstract

If we may paraphrase and adapt from feminist 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. It is important for restoring the image of people as <u>persons</u> rather than as objects of research. As we have undertaken it, the foundational perspective of worldview research is that one must hear from students and science teachers about themselves. We thus suggest it is important for science educators to understand the fundamental, culturally based beliefs about the world that students and teachers bring to class; because, science education is successful only to the extent that science can find a niche in the cognitive and cultural milieus of students. The purpose of this article is to present an new interpretive methodology for exploring worldview presuppositions about the natural world through the language and ideas voluntarily expressed by science teachers and students. The methodology addresses the broad question, <u>What is it that people think about nature or the natural world?</u> The research objective of the methodology is to map the qualitatively different conceptualizations of nature held by people and thus to better understand the place science finds in those conceptualizations. The methodology is a modified naturalistic inquiry, interview technique. The audio taped interviews are semi-structured in that an interview involves elicitation devices designed to encourage a person to talk at length about nature. The findings are assertions based on concept maps and first person interpretive narratives derived from the interviews. The intention is to develop working hypotheses in the form of interpretive assertions through an emergent design. While the method described here is specifically about the <u>essence</u> of nature,

similar methodology is used for investigating other worldview categories with respect to science understanding.

"The proper study of mankind is man."
Alexander Pope (18th century)

"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 psychological ones 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 nicely summarized in C. S. Lewis' two brief sentences quoted 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, & Tarule. (1986) study Women's Ways Of Knowing: The Development Of Self, Voice, And Mind are seminal 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. It is important for restoring the image of people as persons rather than as objects of research. As we have undertaken it, the foundational perspective of worldview research is that one must hear from students and science teachers about themselves. The purpose of this article is to present an interpretive methodology for exploring worldview presuppositions about the natural world through the language and ideas voluntarily expressed by science teachers and students. The methodology addresses the broad question, What is it that people think about nature or the natural world? This question is of interest because nature is the domain of the natural sciences. Thus, one wishes to know the characteristics of how science teachers and their students understand nature. What concepts have scope and power in their thinking about nature? Where does science fit into their thoughts about nature? How is science interpreted when it has become an integral part of a person's thinking about nature? How do science teacher and student conceptualizations of nature compare? In a separate article (Part II), Cobern, Gibson, and Underwood (199X), report the findings from a study with ninth grade students that employed this methodology.

The Theoretical Framework

People are purposive, intentional beings. People are habitual creatures 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." Worldview research thus takes it as axiomatic that the more educators know about students and teachers as people the better educators will be able to teach people as students. Among others, Fenstermacher (1979), Hawkins and Pea (1987), Lythcott (1991), and Shymansky and Kyle (1992) espouse 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; 1994) 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 intensity at any one point is likely to be low (Jones, 1972). One also knows from wise philosophers, such as John Dewey and Nel Noddings, that the totality of a person's experience is continuous and one would think that science is very much part of a science teacher's everyday thinking. Many learners, however, 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 this phenomenon of boxing off science as school knowledge. It is cognitive apartheid (Cobern and Aikenhead, in press). 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 should at least be considered that the ways in which science teachers and professors have interpreted science within their own everyday thinking will influence how they teach science. And, it is not at all clear that teachers and professors will immediately recognize important connections among ideas and experiences that students make but which differ from the connections teachers and professors personally make. Therefore, as one gains knowledge of the presuppositions students and teachers bring to the classroom, one gains insight into how learning environments can be more effectively structured. These presuppositions, however, can be about anything; and as Neil Postman (1985) says about modern culture, one could easily drown in a sea of irrelevance. To avoid this we grounded our research in a logico-structural theory of worldview (Cobern, 1991, Kearney, 1984) which provides 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, Classification, Relationship, Causality, Time, and Space. The theoretical work was extended in Cobern (1993b, 1996) and applied to empirical work in Cobern (1993a), Cobern et al (1996), Lassiter (1993), Lawrenz and Gray (1995), and Ogunniyi et al. (1995). Related work has been done by Allen (1995) and Lynch and Jones (1995). The methodology described in this article has to do with the NonSelf. "The NonSelf can be divided into domains of... human environment and physical environment, or society and nature... Most cultures, including Western culture, have preferred Redfield's tripartite division: Humanity... Nature, and God..." (Cobern, 1991, p. 45). More specifically, the methodology described in this article focuses on that subdivison of the NonSelf known as <u>nature</u>, or the natural world. By way of definition, 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, 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) are all significant contributions 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 (1983) 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, of course, does not necessarily lead to reckless individualism nor to the wanton exploitation of nature (Young, 1974). There are, however, those who believe that it does so necessitate and they are not always gentle in their expressions and acts of opposition. 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 not only of all animal experimentation in science, but as well an end to meat, leather, and wool industries (Foote, 1992; Los Angeles Times, 1989, p. A6; The World & I, 1995, vol 10, no. 4, p. 356-383). The radical activists demonstrate how serious worldview differences can be. That the differences can lead to anti scientific views has not gone unnoticed among some scientists. Warnings have been sounded by Holton (1993), Gross and Levitt (1994), and Theocharis and Psimopoules (1987) among others.

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 suggest that mechanistic-reductionism is a prevalent view of nature in Western science education. Is it wise for educators to assume that students coming into the science classroom will fully accept as both appropriate and important the image of nature projected there, when the literature indicates that there are many views of nature? Indeed, given the criticism of modern, Western scientific views of nature (e.g., Merchant, 1989), should one not investigate the views fostered in a science class? If one grants the important tenet of cultural studies that all ideas including scientific ones are expressed within a cultural system (Cobern, 1996), then one should ask, How does the cultural system of the science teacher and curriculum compare with the system or systems brought by the students? How do students and teachers 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 in thinking about nature? These are the cultural questions based on Geertz' (1973, p. 5) view that culture is about "webs of significance." The purpose of this article is to describe an interpretive methodology of asking such questions.

These questions, moreover, suggest an alternative view of scientific literacy and literacy assessment. The elimination of scientific illiteracy is the principle and historic objective of science education at the school level. Scientific illiteracy is typically defined as a kind of cognitive deficit, to use Layton’s (n.d.) and Jenkins’ (1992) description, assessed by quantitative measures involving both science concepts and processes. The NAEP (1979) and Miller (1987, 1988) assessment series in the USA 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 <u>other</u> 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 in contrast to scientists and science educators 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 questions explicitly about science such as asking for an explanation of a particular science concept or the construction of an experiment to test a scientific hypothesis. No, the acid test is whether science has become an authentic part of a person’s everyday thinking. Thus, the methodology reported here asks: To what extent do people enjoin scientific knowledge vis-à-vis other domains of knowledge in a discussion about nature (a topic that most people do not explicitly associate with science), given that science is unarguably relevant to the topic of nature? Moreover, what <u>are</u> the concepts that appear to have scope and force in a person’s thinking about this topic? For it is one thing to be able to give correct answers on a science exam. It is quite another thing to appropriately use scientific knowledge 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 <u>when</u> and <u>how</u> students apply their knowledge" (also see Heath & McLaughlin, 1994). It is <u>also</u> important to understand how their science teachers think about scientific knowledge.

An Interpretive Methodology

The research objective of our methodology is to map the qualitatively different conceptualizations of nature held by people, or what might be called <u>terrain of belief</u> regarding nature (also see Jones, 1972, and Marton, 1988), and thus to better understand peoples' conceptualizations of nature and the place science finds in those conceptualizations. While the method described here is specifically about the <u>essence</u> of nature, Cobern, Gibson, and Underwood (1995b) describes similar methodology for investigating other worldview categories with respect to science understanding. Our worldview methodology is a modified naturalistic inquiry, interview technique (Kvale, 1983; Spradley, 1979) with constant comparative analysis (Lincoln & Guba, 1990) and assertion development (Strauss, 1987). The audio taped interviews are semi-structured in that an interview involves elicitation devices designed to encourage a person to talk at length about nature (Bliss & Ogborn, 1987). The findings are assertions based on concept maps and first person interpretive narratives derived from the interviews. The intention is to develop working hypotheses in the form of interpretive assertions through an emergent design as advocated by Cronbach (1975), Lincoln and Guba (1990), and Strauss (1987).

In a pilot study, high school and college students were asked to write, in one instance, a few sentences about the meaning of nature or the natural world. In a second instance, students were asked to write five words they associated with nature or the natural world. In Japan, Ogawa (personal communication) conducted a very similar exercise. In both cases, the researchers found that the student responses contained such variation as to be uninterpretable. It was clear that many students used the words nature and natural world in ways very different from their standard dictionary, philosophical and scientific definitions. This problem is overcome by beginning an interview with a focusing event. The focusing event is designed to insure that an informant has a basic understanding of what the interview is about without suggesting too much about the attributes and value of nature. Specifically, the interview begins with the informant viewing a set of six natural landscape photographs depicting nature at micro and macroscopic levels (including outer space), and nature as both benevolent and dangerous. People and human constructions are shown in only one photo and this is the photo intended to show the power and danger of nature. The object and number of photographs can vary but the photographs must be carefully chosen so as not to over represent any one perspective of nature. After given a few moments to examine the photographs, the informant is asked if these pictures are of nature or the natural world. In our experience, the only picture that informants occasionally have doubts about is the picture of outer space. Occasionally a person is unsure that “space” is part of nature but this is a minor point which we have not found to interfere with the interview procedures. The informant is then asked whether the words “nature” and “natural world” name the same concept. Again, our experience has been that most informants say they do. When an informant says they name different concepts, the researcher asks for an explanation and then decides what term is the best one to use for the rest of the interview. At this point, the informant is asked the grand tour question, How would you define nature, that is, the natural world? The researcher may ask for clarification of things not understood, but the intention here is for the informant to give an open statement about nature without any discussion that may inadvertently be suggestive. It is crucial to note that at no time during the interview does the interviewer initiate a question or comment about science. It is solely up to the informant to bring science or any other topic into the discussion. Once an informant has spoken of science, it is of course both appropriate and necessary for the interviewer to follow up on the comment. The basic interview protocols we use are given in the Appendix.

After the informant's opening statement the interview proceeds with three tasks in the form of <u>elicitation</u> <u>devices</u> employed to elicit conversation beyond what the grand tour question and photographs could accomplish alone. As stated earlier, this methodology is about <u>hearing</u> from people. The concepts that one wants to hear about (nature, in this case) are, however, quite profound and not easily addressed extemporaneously. Thus, one cannot simply ask a person, on the spot, "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, our methodology uses elicitation devices which are multi-directional prompts, that is, each device prompts in many directions at one time. It is up to the informant to decide which of the many directions to take. The elicitation devices comprised three word and sentence sets (see Figures 1 and 3) drawn from pilot studies, but primarily from the literature on the concept of nature in Western thought (e.g., Cobern, 1991, Glacken, 1967; Merchant, 1989; Thomas, 1983). The categories of epistemological, ontological, emotional, and status shown in both Figures 1 and 3, and the sub categories in Figure 3 are drawn from the literature and used here to insure a wide variety of words and statements. As will become evident later, these categories do not directly influence the analysis of the interview tapes. Rather, terms are interpreted on the basis of the meanings given by the informant.

Across the three tasks the device content partially overlaps allowing the informants to be persistently engaged by concepts relevant to the issues over the three tasks, thus minimizing the potential for unrecognized insincere comments. The built in overlap also allows triangular analysis of codes to improve the trustworthiness of interpretation. The idea of the elicitation devices is that an informant <u>thinks aloud</u> about nature in response to the devices. The interviewer, consistent with Spradley (1979) and Kvale (1983), is there to ask probing questions and to encourage the informant to speak freely and at length. With adults the interview can be conducted in one sitting of 40 to 90 minutes. With adolescents the interview is conducted in two sittings. Task One is done in the first sitting of 40 to 60 minutes and Tasks Two and Three are done in a second sitting of about the same length. In our experience, the interviews with adolescents take longer than interviews with adults. We found adolescent students to be less sure of their ideas and more deliberative. They simply took more time to say what they had to say.

<u>Epistemological Description</u>: (Reference to knowing about the natural world.)	confusing mysterious	unexplainable unpredictable	understandable predictable knowable
<u>Ontological Description</u>: (Reference to what the natural world is like.)	material matter living complex orderly beautiful	dangerous chaotic diverse powerful changeable	holy sacred spiritual unchangeable pure
<u>Emotional Description</u>: (Reference to how one feels about the natural world.)	peaceful	frightening exciting	"just there"
<u>Status Description</u>: (Reference to what the natural world is like now.)	"full of resources" endangered	exploited polluted	doomed restorable

Figure 1. Task One Terms

Task One

The elicitation device in Task One is a set of thirty-three words shown in Figure 1. Each word is taped to a 3X5 card. After the grand tour question, the interviewer begins by randomly sorting the words into three equal groups to be shown to the informant one group at a time. This simply gives the informant a more manageable number of words to work with at one time. The interviewer spreads a group of cards on the table and asks the informant to sort the words into two groups according to which sentence, "Nature is _____" or "Nature is not _____," the informant would use a word to complete. (It helps to have these sentence starters visible as signs on the table.) If an informant wishes, a middle or undecided group is acceptable. The sorting procedure is repeated for the second and third groups of words. The interviewer then spreads before the informant all the “nature is” words and asks the informant to form subgroups of words which represent (from the informant’s perspective) similar or related concepts with respect to nature (see Figure 2). Up to this point there is a minimum of interaction between the interviewer and informant. Now begins the discussion.

1st group	**Later group**
chaotic	understandable
dangerous	orderly

Figure 2. Example groups of words

The informant is asked to pick a group of words (or it may be a single word) with which to start the discussion, for example, the first group in Figure 2. The interviewer simply asks what the informant would first like to talk about (see protocols in the Appendix). When a group (or single word) is chosen the interviewer proceeds with questions such as, What is the thought about nature conveyed by these words? What was the reason for forming this group of words? The interviewer asks for examples, plays "dumb" and asks for further explanations. Depending on what one sees in the word group the interviewer may pick out individual words and ask for more information (especially if words seem to conflict). Once the discussion of the first group is exhausted, the interviewer sets the group aside (but within sight) and asks the informant to choose the next group (or word). The process is repeated except now the interviewer asks, Why is this group second rather than first? Is there any connection between the first and second group? How are they different or alike?

It is important for the interviewer to remain alert for contradictions and ambiguities as the interview proceeds through the word groups. For example, in Figure 2 the right hand group may have been the seventh group discussed but it would have been important for the interviewer to call attention to the difference between the seventh group and the first. In this example, the interviewer might ask, In what sense is nature both chaotic <u>and</u> orderly? And, while there is no specific set of questions that interviewer asks, there is a set of questions the interviewer uses as a guide for his or her questioning strategy during an interview. These are:

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

These heuristic questions are important for uncovering scientific ideas without directly asking about science. For example, an informant might comment that, “Some people study nature for a living.” To which the interviewer would respond, “Who does this?” At this point the informant might say that scientists do this and if so the interviewer might ask, “What do you think about science? Does science have anything to do with nature?” As previously mentioned, however, at no time does the interviewer introduce the word “science.”

Task One is complete when the above process is repeated for all words in both the "Nature is" and "Nature is not" groups (and the undecided group if used). If there are to be two sittings, the first sitting ends with the interviewer repeating the grand tour question, How would you define nature, that is, the natural world? If there is only one sitting, then the interviewer moves on to Tasks Two and Three.

Tasks Two and Three

The elicitation device for both Tasks Two and Three is the same set of eighteen sentences shown in Figure 3 with each statement printed on a 3x5 card. If Task Two is done in a second sitting the interview begins by asking the informant to recall again his or her definition of nature. Subsequently, two signs are displayed before the informant, "Agree" and "Disagree," and the informant is shown all eighteen cards. The informant is asked to divide the cards into two groups, i.e., those with which the informant is in general agreement and those against (again, an undecided group is allowable). The informant is then asked to separately review the two groups, and from this point on the procedures are identical to those for Task One.

The sentences of Tasks Two and Three provide a significant amount of redundancy with Task One as can be seen in the categories used in both Figures 1 and 3. The sentences are more suggestive than the words in Task One. At this point, however, the informant has already established his or her preferred viewpoints through the sorting of words in Task One. The sentences of Task Two give the informant the opportunity to bring more focus to issues concerning epistemology, ontology, emotions vis-à-vis nature, and perceptions of the current status of nature. An informant can further develop ideas because there is sustained engagement with the topics. The statement devise also provides more specific prompts in some areas. This is done because concepts cannot always be adequately represented by single words. In Task One the words holy, sacred, and spiritual are meant as religious words but not all informants use these words in a religious way. An informant who rejected all the religious words in Task One as not applying to nature might still pick the sentence "I see in nature the work of God" as an important idea. The status words from Task One are treated similarly in Tasks Two and Three.

By the conclusion of Tasks One and Two, the informant has spoken at considerable length on the subject of nature. Now the person is in a much better position to pin point the ideas about nature that are of most importance to this person. That is what Task Three is about. Task Three is a dyad statement, ranking task. In Task Three the informant is shown random combinations of two sentences from Task Two. The informant is shown the first two randomly chosen statements and asked to discard both, keep both, or keep only one depending on how strongly the informant agrees with the statements. Then the interviewer randomly selects a third statement which the informant compares with any statements kept from the first comparison. Again the informant must decide whether to keep or discard the new statement. The informant may also change his or her mind about previous statements. At this point the informant may choose to keep all showing sentences or discard one or more according to how strongly the informant agrees with the statements. This process is repeated until all 18 have been drawn. During the process the informant is asked to keep the retained sentences in rank order. An informant has the latitude to reorder the sentences as new ones are drawn and kept. When all sentences have been drawn, the informant is asked to check the rank order one last time before the interviewer records the order number. What is left on the table are the rank ordered statements about nature with which the informant strongly agrees. It is crucial to note that although Task Three is essentially a ranking task, the interview incorporates a think-aloud procedure. This affords the informant one more

<u>Epistemological Description</u> (Reference to knowing about the natural world.)	**(a) Knowable:** 1. Nature is something that should be studied so that we can learn more about it 2. It is important to understand how things work in nature. **(b) Unknowable:** 3. Nature is difficult to understand. 4. To me nature is mysterious.
<u>Ontological Description</u> (Reference to what the natural world is like.)	**(a) Super naturalistic:** 5. I see in nature the work of God. 6. I find in nature a spiritual quality 7. Nature is the result of purpose and things happen in nature because of purpose. **(b) Naturalistic:** 8. I view nature as something solid, substantial and reliable. 9. Nature is the material, concrete world around us. 10. The natural world is all there is, all there ever was, all there ever will be. 11. The material world of nature is the only real world there is.
<u>Emotional Description</u> (Reference to how one feels about the natural world.)	**(a) Positive:** 12. I see beauty in nature. 13. I have an pleasant emotional response to nature. **(b) Neutral:** 14. Nature is an everyday part of life that I generally do not think much about.
<u>Status Description</u> (Reference to what the natural world is like now.)	**(a) Resource Orientation:** 15. Nature is a very important resource: water, energy, food, materials for making things. 16. Without the things that we get from nature we could not enjoy the lifestyle we have today. **(b) Conservationist Orientation:** 17. I believe nature needs to be protected. 18. I am concerned about pollution and the damage it does to nature.

Figure 3. Statements for Tasks Two and Three

opportunity to discuss the statements and insures that the interviewer knows how the informant is interpreting the sentences. The interview ends with a repeat of the grand tour question followed by the question, "Please tell me something that you know about nature that is quite important?"

Analysis of Data

The analysis of data begins with the transcription and coding of the interview tapes. Transcripts are coded by assigning code words, which represent chunks or pieces of information within a transcript, to transcript line number. Codes can be embedded within line numbers assigned to other codes, and the same set of line numbers can be co-coded with two or more codes. Some of the code words used in our research were taken from the Task One prompt words, but many came from the transcripts themselves (i.e., words used by an informant were used as codes). In addition, other codes are chosen by the researchers as needed. Whenever possible it is advisable that coding be done by a caucus of two researchers with a third researcher coding independently of the first two. Afterwards, the coded transcript is analyzed by all three together to iron out disagreements. The codes and code definitions are subsequently kept in a lexicon so that they can be used consistently throughout the coding process.

Once the transcripts are coded, a computer program (e.g., The Ethnograph or HyperQual) facilitates the sorting and printing of text segments by code words. The text printouts associated (by line numbers) with each code also list embedded codes and co-codes for the same set of line numbers. These segment printouts by code word are summarized on a worksheet (see Figure 4) that is attached to the printed segments for each code word. These sorted and collected segments allow for the review of text associated with the code words which is important during the construction of concept maps (see Figure 5). The construction of a concept map provides an organized overview of what was said by the informant during the interview, albeit an interpreted overview. The concept map helps identify the ideas that appear to have the most importance for the informant and how various ideas are related. Major entries in the concept map (e.g., "Beautiful" in Figure 5) serve as first level entries for an outline later to be used in the narrative construction. The ideas in the concept map underneath each major idea (e.g., "Picture" in Figure 5) become the secondary entries in the outline. The importance of an idea is gauged by its appearance across all three tasks, the number of times it is mentioned in the interview, by the informant's voice inflection, and what weight it is explicitly given by the informant.

Line Numbers	Embedded in Code Words:	Searched for Code Word	Co-Codes:	Embedded Code Words:	Comments:
23-48	*Knowable*	<u>*Science*</u>	*Order*	*Learn*	
56-62		<u>*Science*</u>			
123-167	*Order*	<u>*Science*</u>	*Biology*	*Chaotic* *Mysterious*	

Figure 4. Code Summary Work Sheet

Using the structure provided by the concept map and using content taken directly from the transcript, the researchers write a <u>first person interpretive narrative</u> for each informant. The process proceeds by following the order suggested by the concept map and shown in the outline. Following this code order, the text under a code (e.g., Order) is copied into a text file. <u>Using as much of the student's language as possible, the raw text is worked into a coherent paragraph or set of paragraphs</u>. This is done for all the code words, following the outline, until the researcher

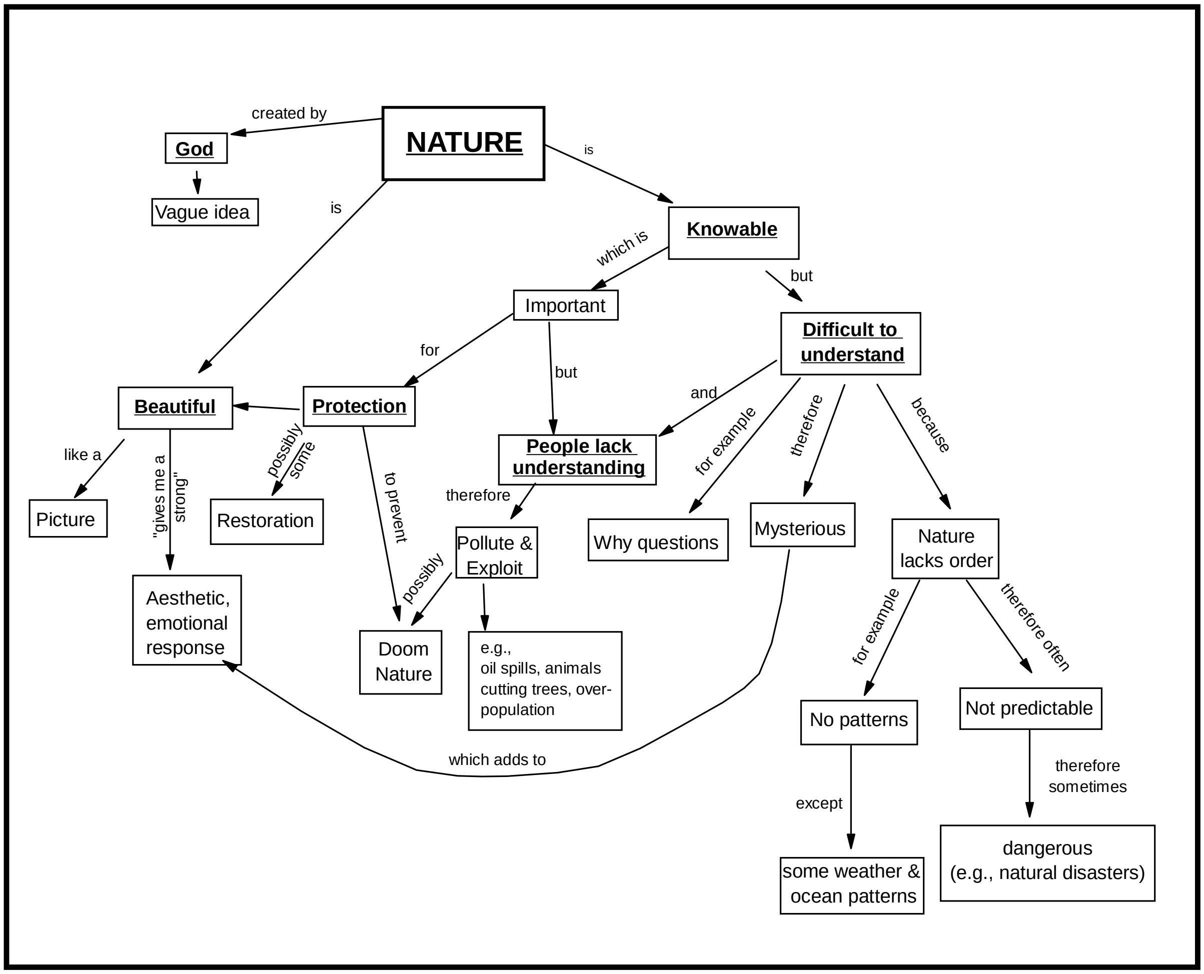

Figure 5. Example Concept Map From a Ninth Grade Student

Although I've thought a little bit about the natural world, 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. Some things like weather and ocean patterns can be predicted but many dangerous things might not be predicted - earthquakes and natural disasters, for example. Animals also do things that we don’t understand and can't explain. Some aspects of nature are knowable and it is important that we learn more about it. What we learn comes from both school and personal experience. Our lack of understanding of nature has caused us to exploit our natural resources. Ultimately we are causing permanent damage because of such things as overpopulation, oil spills, cutting down trees, pollution, etc. Possibly we are doomed. We might be able to do some restoration that might help solve some of our problems.

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. Though I understand only a little about it, I like the mystery of not understanding everything. It adds to the beauty. Nature can be peaceful, with calm breezes, lots of nice trees and no trash. I also have some religious feelings about nature. Not necessarily those of any one particular religious group. I do think that some god created the earth. This confuses me also. I'm not entirely sure of my beliefs but I do think that a god created the earth.

Figure 6. Example Narrative for Map in Figure 5

is confident that all useable text has been incorporated and that the informant’s ideas are accurately represented. Narrative construction of this type takes many iterations of cross examining the draft narrative with the concept map, outline, and text segments. Once the process is complete, the informant is shown the concept map and narrative for review and comment.

After discussion with the informant, the researcher constructs the final versions incorporating the informant's editing where appropriate. Final concept maps and narratives vary in complexity and length, respectively. The examples in Figures 5 and 6 are relatively simple. Figure 7 is the concept map for a physics teacher and it is clearly much more complicated. Moreover, the narrative for a science teacher or professor can run three to four pages in length.

Through out the process from interviewing to coding to concept map and narrative production, the researcher should be alert for possible assertions that stand out in the data or in various ways occurred in the researcher's deliberations and thinking about the data. These <u>tentative</u> assertions are logged for later use. With the finalized concept maps and narratives in hand, the researcher begins the formal process of sorting, comparing, and cross checking cases (informants) by major code categories. For example, a first analysis might divide cases by gender and examine for within group code consistency and cross-group code differences. Other comparisons we have used involve the examination of cases by the codes: religion, aesthetics, knowable, science, order, and conservation. This process led to a list of 37 tentative assertions in the study reported in Part II (Cobern et al., 199*). In that study the 37 tentative assertions were grouped and reduced to seven semi-final assertions. The penultimate step is to cross check each semi-final assertion against each case for confirming and disconfirming data. The researcher then constructs a narrative argument for each assertion drawing upon the first person interpretive narratives of each case in the study. The final step of the analysis process is to have the assertions and arguments externally validated by one or more qualitative researchers not involved with the study. These validators cross check the assertions, supporting arguments, and examples against the case concept maps and narratives.

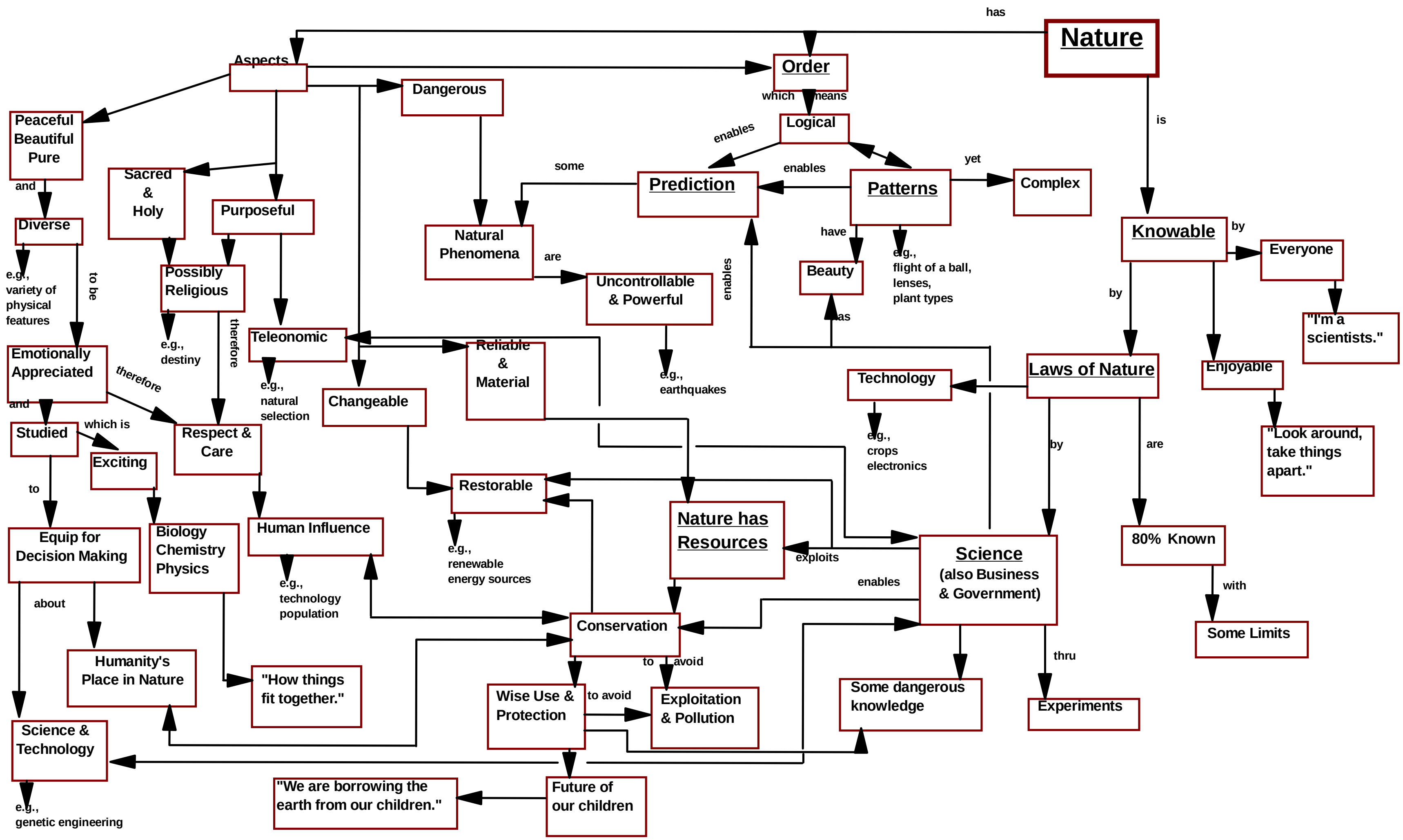

Figure 7. A High School Physics Teacher

The analysis ends with the researchers revising their work in light of the external validation findings. It is at this point that the researchers discuss the implications of the research

This assertion development procedure represents a change from the bi polar code analysis that was used in the first conceptualizations of nature study (Cobern, 1993a). The assertion analysis approach is more typical of qualitative research (Gallagher, 1991; Denzin and Lincoln, 1994) and has the advantage of greater familiarity in the research community. Moreover, in recent research, the statement form of assertions was found to be more informative than bi polar codes when considering the research and instruction implications of the research (Cobern, Gibson, & Underwood, 1995a).

Conclusion

We began this article with the thought that it is important to hear from people and that worldview theory suggests several interesting areas related to science education worth hearing about. The methodology addresses the exploration of the worldview category nature, asking of people, What is nature? Though the syntax is simple, this question is quite profound and anything but easy to answer. In recognition of this the methodology involves elicitation devices designed to unobtrusively suggest many things about nature of which the informant in an interview setting is free to pick and choose. The eventual research products are concept maps and first person interpretive narratives. Obviously, what one does not have is a score of any type. Instead the maps and narratives provide the flesh, muscle and sinew of an authentic point of view concerning nature and scientific concepts used to understand nature, and from which assertions can be derived. The assertions can be used to address specific research questions. Among others, these include:

- In what ways, if any, do teachers' conceptualizations of nature influence their teaching?
- To the extent that a teacher's conceptualization of nature enters the classroom, what interactions take place with student conceptualizations of nature?
- How do student conceptualizations of nature vary with other factors such as gender, age, family culture, ethnicity, or language?
- How can a teacher work with student conceptualizations of nature for the purpose of more effective science learning?
- What elucidation can this methodology bring to the differences and similarities among high school and college science teachers of different disciplines or between high school and elementary teachers?

These are only a few of the questions that could be addressed and these do not even include questions about other worldview categories such as Causality. The assertions can also be descriptive. Indeed, the presupposition to the above questions is that a researcher has descriptive accounts of both students and teachers. In Part II, we offer just such a descriptive account of ninth graders everyday thoughts about nature.*

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Appendix: Basic Interview Protocols

What follows are the basic Task One interview protocols as written for student interviews. The protocols for Task Two are basically the same. The protocols are appropriately modified for use with adults. An interview begins with a few introductory comments when the informant enters the room:

"Hi,"
"Have a seat,"
"Thank you for coming," etc.
"I think I have everything set up that I need except for your permission slip. Did you bring it with you?"
"I want to assure you that this is not a test. We are going to have a conversation about your concepts of "nature" for a study that is being done at the university."
"I'll be taping part of our conversation because I think we might be talking too fast for me to write everything down."

Subsequently, the interview proceeds as follows:

INTERVIEWER DOES	INTERVIEWER SAYS
Spread out pictures and let student look at them.	"I've laid some pictures out in front of you, would you just take a moment to look at them?" Pause
	"How would you define <u>nature</u> or the <u>natural world</u>?" Pause
	"Is there any difference or are they essentially the same thing?"
If a distinction is being made - combine definitions or otherwise resolve.	
	"Would you say that all of these pictures depict <u>nature</u> or are there some that <u>do</u> and some that <u>do not</u>?"

INTERVIEWER DOES	INTERVIEWER SAYS
Put up signs: NATURE IS... AND NATURE IS NOT...	
	"We are going to go through a series of cards. I'm going to ask you to think about the words and then I'll ask you to comment about them."
Divide cards randomly into three groups. Use 1/3 at a time. Lay out 1/3 of the cards.	
	"Remember, what we are focusing on is what nature is. I want you to divide these cards into two groups. One group of words that you would use when talking about nature and one group that you would not use."
Repeat for each 1/3 of the cards.	
Take words in the would use pile and spread them out in front of interviewee.	
	"Some of these words may be about the same thing - do you want to lump any of these words together?"
Turn tape recorder on if it hasn't been turned on yet.	
Wait for student to pick.	"O.K., let's talk about these groups. Which of these would you pick out 1st to talk about "what nature is?" “Fine"

INTERVIEWER DOES	INTERVIEWER SAYS
<u>Repeat</u> chosen words for tape.	"What do these words have in common? Why have you put these words together?" etc.
Ask clarification questions if necessary. Avoid “Okay.”	
	Why are you saying `<u>nature is</u> __________**?** What do you mean when you say `<u>nature is</u> ____________ **?** In what sense would you say `<u>nature is</u> ____________**?** What examples can you give me?
Ask non directed questions that invited the interviewee to talk about why the terms were picked and what they mean. Ask for clarification and examples. Ask follow up questions were appropriate.	
Pull 1st group of words aside but keep them visible.	
	All right, we have this group aside now let's take a look at the rest. Which group would you pull out next?
	"Why did you pull <u>this</u> group out after this group?"
Go back through the question series as above. Look for conflicting words. As how first group relates to second or if they do.	

INTERVIEWER DOES	INTERVIEWER SAYS
	Can you help me understand this? Why is it .... on the one hand (name first or previous groups) and on the other it its (name present group)?"
Try for at least 4 groups of "Nature is." Do all if interviewee is prepared to continue - then go to "Nature is not."	
Repeat questioning as above.	

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