

Different Perspectives on the Natural World: Biology Professors and Their Students
(AKA: Breadth vs. depth: a comparison of student and professor conceptualizations of nature"

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William W. Cobern, Ph.D.
Associate Professor of Science Education
Arizona State University West
Phoenix, Arizona
85069-7100

602/543-6334
E-Mail: ICWWC@ASUACAD

The science classroom is the location of complex interactions between students, teacher, curriculum, and environment. These interactions can lead to conflict where the various factors pertaining to students, teacher, curriculum, and environment are at odds. Interest in these types of conflicts has led to numerous studies of classroom processes including those concerned with gender, ethnicity, religion, and language (e.g., Fraser, 1989). Worldview is a factor of more recent interest to researchers and is at an early stage of methodological development and nascent investigation (Cobern, 1991c). Pertaining to the classroom, worldview research focuses on the fundamental beliefs held by teachers and students, and embodied in science curricula. It is supported by the conviction that "scientific knowledge and practices must be interpreted within specific social contexts" (Shymansky & Kyle, 1991, p. 2) which I take to include the context of cognitive culture. The research objective is to gain a better understanding both of worldview variation across a spectrum of students, teachers, and curricula, and of the interaction among worldviews in learning situations.

Presentation Purpose: Ten years ago Easley (1982) argued that research needed to penetrate the world of individual teachers. More recent research on teachers' lives (e.g., Goodson 1991) responds to that need as does worldview research. At this meeting, I am reporting on a study of how four biology professors conceptualize nature. This focus on teacher context is a companion study to research involving college students in a biology course reported last year (Cobern, 1991a; in press-a). Together, the two studies allow for the limited comparison of one aspect of student and professor worldviews.

Theoretical Background: According to constructivist theory learning is the process of building up conceptual frameworks in a meaningful fashion (Ausubel, 1968). The building process is an interpretive process grounded in prior knowledge. As an aid in thinking about meaningfulness and interpretation, I have borrowed an analytical scheme from semiotics. Though what counts as meaningful varies with the individual, for all individuals meaning is the ternary relation between *concept*, *sign*, and *learner* (see Figure 1). Meaning is not something that resides in any one place or object, but a relationship spawned by the confluence of concept, sign, and learner. The *learner* is the student who brings to the confluence a socially developed web of meaning constructed from a myriad of previous ternary relationships. Thus, to better understand how students construct meaning

in the science classroom, one must know more about the webs of meaning they come with. Prior conceptual knowledge is a major component of cognitive context and this is the focus of misconception or alternative conceptions research (e.g., Novak, 1987). This aspect of context is commonly discussed. The social and cultural contexts students bring to the classroom have received much less attention. I accept Geertz' definition of culture, "man is an animal suspended in webs of significance he himself has spun, I take culture to be those webs..." (1973, p. 5). Cobern (in press-a) was an attempt to elucidate certain fundamental ideas that form a section of those webs of significance for a select group of college students. The ideas were those about the natural world. The importance of that research is grounded in the assumption that what one fundamentally believes about nature is an important influence on the construction of scientific knowledge.

In a science classroom, *sign* refers to the symbolization or representation of science concepts in a teaching episode. In other words, scientific concepts as offered to the learners by the teacher are in fact the teacher's interpretations of scientific concepts. A similar statement can be made about textbook authors, but the influence textbooks is beyond the range of the current study (for related research on textbooks, see Ausubel, 1966, and Sutton, 1989). As with students, the research on teachers has tended to focus on scientific knowledge. However, if what a teacher presents in a classroom is an interpretation of scientific concepts, then to better understand how science comes to be represented in a teaching episode one must know more about the social and cultural context, those webs of significance, the teacher brings to the classroom. Thus, the researcher is led to ask:

1. What is the description of the teacher's personal context on which his or her interpretation of scientific concepts is founded?
2. How does this description of teacher context compare with student descriptions?
3. What happens to student learning when contrasting teacher/student contexts meet in the science classroom?

These are questions about culture. I have chosen to address the cognitive aspects of culture from a worldview theoretical perspective.

Worldview is a fundamental expression of cognitive culture. It provides the "webs of significance" that Geertz (1973, p. 5) spoke of. Specifically, worldview theory is about

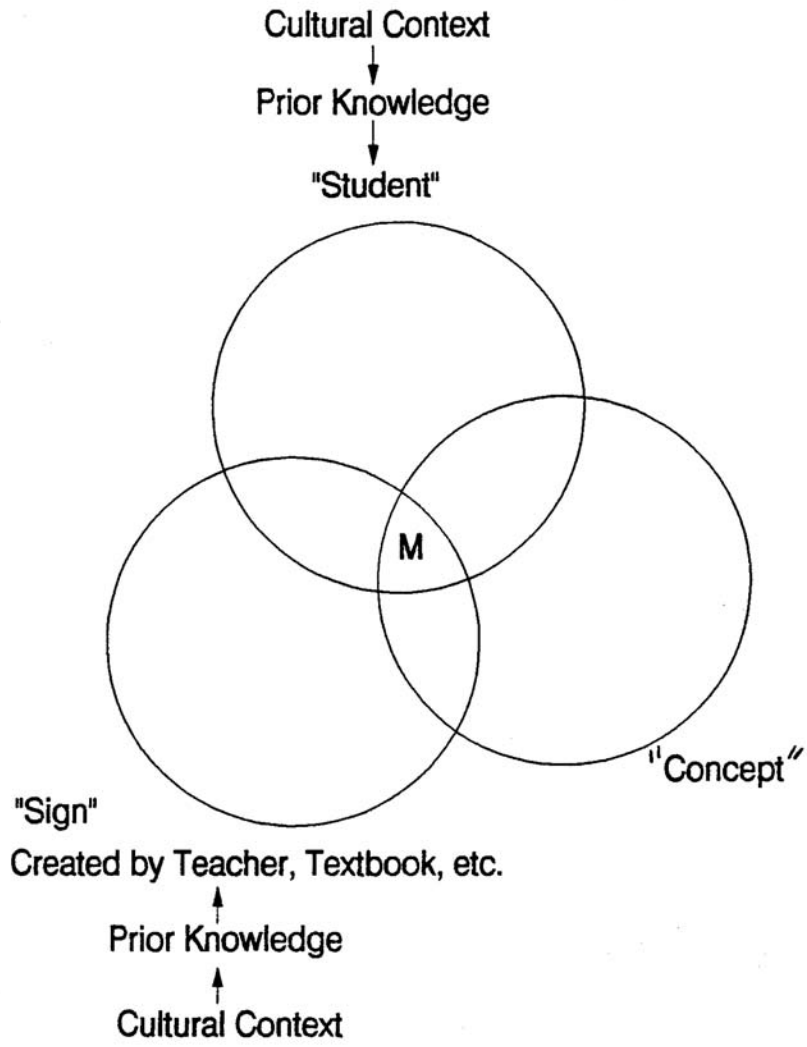


Figure 1. The creation of meaning

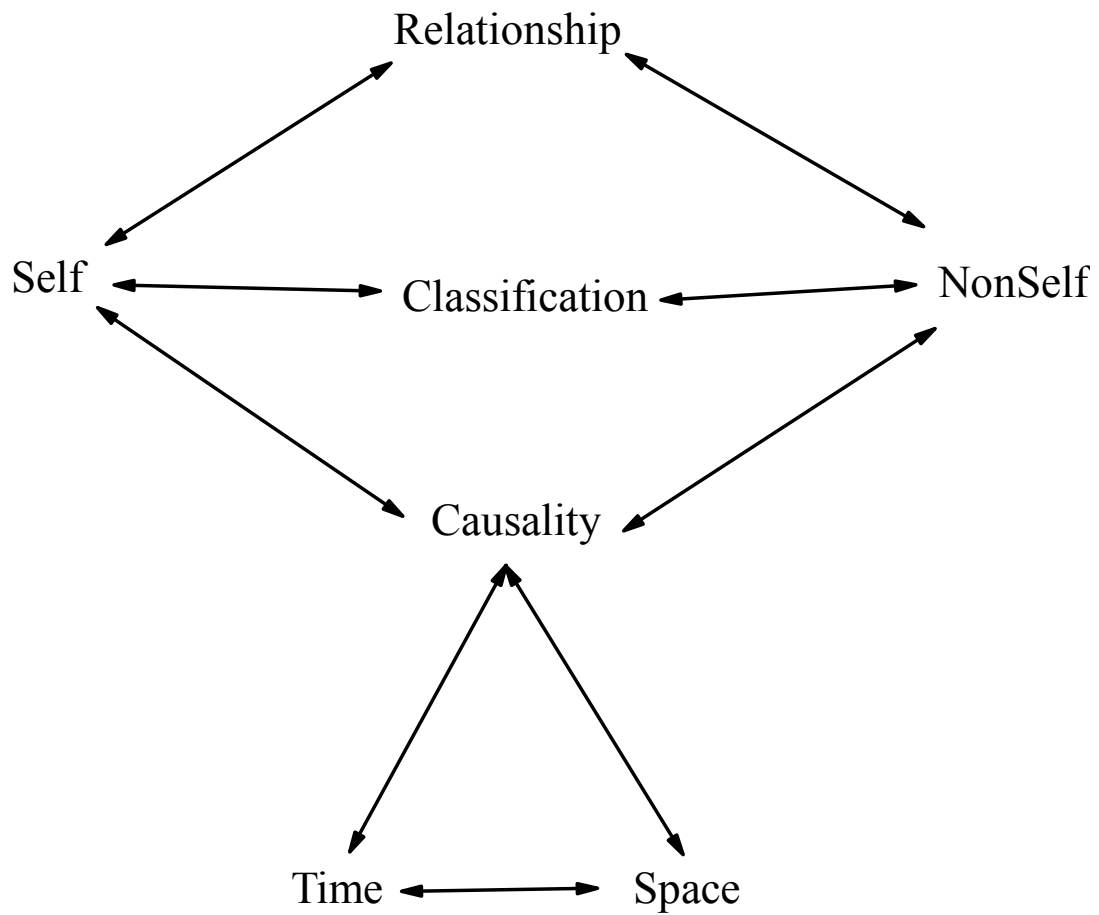
fundamental, culturally derived and supported presuppositions which form an interpretive foundation upon which conceptual frameworks of knowledge are built. Worldview is intimately related to religion and metaphysics. In brief, worldview refers to what one believes the world is really like at the most general level. For example, to see purpose in the natural world rather than "a random collocation of atoms," to borrow a phrase from Bertrum Russell, marks a significant difference in worldview.

The difficulty of doing research regarding worldview is the inherent complexity of worldview. Logico-structuralism is a theory from cultural anthropology designed to provide researchers with a simplified framework for approaching this complexity (Kearney, 1984; Cobern, 1991a & in press-b). Logico-structuralism represents worldview as a set of seven universal categories: Self, NonSelf, Classification, Relationship, Causality, Time, and Space (see Figure 2). The significance of logico-structuralism is that it facilitates the approach to a complex concept without abandoning authentic complexity in favor of simplicity.

In the present study, as in Cobern (in press-a & in press-b), the focus was on Nature. "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, 1991c, p. 45). It is appropriate for science educators to be interested in presuppositions concerning Nature since Nature is the realm in which the natural sciences operate. Moreover, historians of intellectual history argue that views of the natural world as developed in Western culture strongly influenced the emergence and development of modern science (e.g., Foster, 1935; Oakley, 1961; Merchant, 1989). This provides ample reason for suspecting that this aspect of worldview influences both a professor's representation of science in the classroom and a student's interpretation of science in the process of learning.

DESIGN: The first objective of the research was to map the qualitatively different conceptualizations of nature held by a group of biology professors. Such conceptualizations are called outcome space by Marton (1988) and belief space by Jones (1972). This was an interpretive study involving interviewing techniques. The informants were four biology professors at a metropolitan community college, two women and two men. Their ages ranged between 35 and 45 years old. All had doctoral degrees in biology from highly regarded institutions. All had

Logico-Structural Model of Worldview



experience in research before coming to a teaching institution. One professor, in fact, had over 100 juried articles published in bio-medical research journals. These professors were chosen because they were the professors for the nursing students in the companion study.

Data was collected in a series of individual, audio-recorded interviews. As described in Cobern (1991b), the interviews were structured using elicitation devices designed to encourage an informant to reflect on his or her own ideas about nature and to verbalize those ideas. The word "science" does not appear in any of the elicitation devices, nor is it ever introduced by the interviewer. There is an assiduous attempt to avoid any hint that the conversation ought to be about science. An important objective of the interviews is that any mention of, or reference to, science should arise naturally from the individuals being interviewed. The interview audio-tapes were subsequently transcribed. The transcripts were coded by marking transcript segments with descriptive code words (Spradley, 1979; Honey, 1987). From the codes, a smaller set of more general categories were developed as organizers for narratives describing an individual's view of nature, and used along with codes in the construction of concept maps. The principle findings are descriptive categories, brief narratives, and concept maps. These are derived from the transcripts of interviews and highlight both the similarities and differences within the group of four professors. They provide a sense of one aspect of these professors' worldviews.

The second objective was to do a limited comparison of the views held by students and their professors. As noted by Jones (1972), in describing a group it is often convenient if one can arrange codes in bi-polar fashion. For example, Chaotic/Orderly is a bi-polar pair that provides a simple way of showing that views of nature in the group run between "nature is chaotic" and "nature is orderly." This works well when there is a variety of view points as was the case with the nursing students (the pairs from the companion study are shown in Figure 3). The professors, however, were a much more homogeneous group. Thus, while I have compared them to their students using the bi-polar codes developed in the student research, it would be inappropriate to try and describe the professors using those same code pairs.

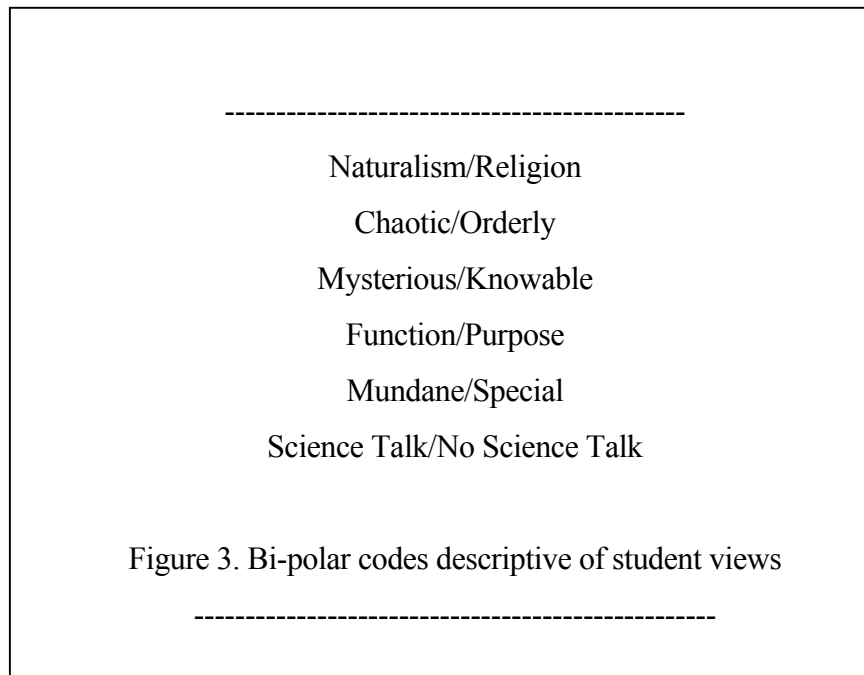


Figure 3. Bi-polar codes descriptive of student views

Results: In the interview settings, the professors talked easily and at length. They were fluid and animated. They warmed to the subject and with no prompting immediately began to speak as scientists. For example, the following excerpt gives one professor's response to the opening question of the interview.

Interviewer: As you're looking at these photographs would you give me your own definition of "nature."

Professor #1: I guess my definition is more biological, when I look at this, sort of, I look at nature as interaction between living and non living. As my area is ecology so I sort of look at nature from an ecological point of view. I always like to look at the interactions.

Interviewer: As you look at these pictures would you say these are all examples of nature or not?

Professor #1: Most of them look like the force of nature... as far as uncontrolled force of nature as far as a volcano goes... a lot of it is uncontrolled fury of nature... beautiful, attractive... as [my] first impression of nature. I always get out when I can, [nature] sort of puts me in perspective of where I am in relation to everything else. Because, when you're out in nature, it's just quite an experience. I mean you realize that you're just a very small, little part of a, of the whole process. It's just so beautiful, you know, to me. Just how these things are formed, how things got to where they are, it's just beauty... its my first impression... attractive...

Interviewer: Can you give me some examples?

Professor #1: I went this past weekend to Cherokeewa National Monument, you know, and

to try to figure out how in the world rock formations could have ever come about, it's mind boggling... that's how I feel. Oh, I've spent a lot of time between the Grand Canyon and Lake Powell. It's just incredible how these forces can come together over a period of time to produce things that look like that.

Interviewer: Can you sort out for me the aesthetic element, visual aesthetic element from... it sounds like you're saying something like "processes" involved in nature?

Professor #1: My first impression was visual... 'cause I, I debated whether I should start with a more, a more scientific impression of it, you know. I, well, I like to look at nature as being orderly. Although people don't like, it's ah, it is orderly but I know there is some discussion about that... I can see the order in nature so my first impression is always from the observer... the "Gee Whiz"... what terrific things... But then I would look back and figure well, put a lot of thought into it and the history of nature, and then, I think I would have to go and look at the progression in nature because that's my education.

As one can see, this professor immediately refers to science. The professor talks about the beauty and appeal of nature, but even these comments are connected to more science oriented comments about order in nature and the forces and processes in nature. Compare these opening comments with the opening comments, in response to the same photographs and question, made by several of this professor's students. The student remarks are typical of the group of students interviewed.

Billie:¹ Natural, not touched, you know, kind of clean.

Denise: [The photographs] kind of look like nature.

Elizabeth: Something that does not have to do with manmade things.

In contrast to their professors, the students' opening remarks were all very brief and most were also very vague. Only one student opened with a science oriented remark.

Carla: I think of nature as everything that pertains to the planet... that arises from the planet... that involves the air we breathe, the oceans, the earth itself, the land, the living organisms that inhabit it.

More typically students spoke of the out-of-doors or of things that were not manmade, and several like Denise above simply found it difficult to offer any definition at all.

As shown in Figure 3, six bi-polar categories were used to describe the students conceptualizations of nature. In contrast, four non-polar categories were derived from the coded transcripts of the professors. Nature is a naturalistic, comprehensible, dynamic, and integrated

¹ All names given for students are pseudonyms

system. Though there was variation, the professors' comments not surprisingly reflected a metaphysical view typically thought of as naturalistic realism.

(For this shortened report I have not excerpted from the professors' transcripts in support of these categories nor provided the concept map.)

Two comparisons may serve to illustrate the difference between student and professor. Even when student and professor were talking about the same notion, their ideas were often quite different. For example, student views ranged across the belief space marked by the codes Chaotic and Orderly as seen in the following excerpts from two student transcripts.

Denise: Manmade things are orderly... but not nature. Nothing is really solid, nothing is really for sure, you know... an earthquake or something... you're not sure tomorrow's going to come. Things don't always happen the way we think they're going to happen, so it is not orderly the way manmade things are.

Carla: I'm a science major and... it's everything I've been taught that everything has an order to it... a system to it.

Denise saw chaos in nature. For all of her success in science courses, she apparently has not come to think of nature as having order. In contrast, Carla is perhaps too impressed. She seems certain that nature is not chaotic at all, but quite orderly. In contrast to the students' divergent views on chaos and order, their professors all held similar views. In the words of one:

Professor: I look at nature as being orderly... although... I know there is some discussion about that... you know, you can't explain everything, but... it is an orderly process... You can't necessarily explain when a volcanic eruption may or may not take place, but... volcanic activity can be predictable. There are patterns from the order of the cell all the way up to the order of a community.

The professor is aware that knowledge is based on order but that the notion of order in nature is somewhat ambiguous and controversial. The other professors held similar views though their language and emphases varied. There was consensus among the professors but the students divided roughly into three groups. Some students such as Carla seemed to see in nature a rigid orderliness while others saw chaos. A third group of students held balanced views similar to their professors. They viewed nature as a dynamic system involving both order and change.

Metaphysics provides another example of how differently professors and students can respond to the natural world. Jackie is struck with awe by what she sees in nature and this prompts a

religious expression.

Jackie: There are a lot of unknown things about nature. I wonder about all of them. I wonder about the little insects in the forest and things like that so it's a mystery to me how it's things all fit together and works together... I get this feeling it's like a special place... it's kind of holy... nature just gives me a very special feeling, I mean, when I'm like out in the woods... the beauty and the mysteriousness of it all and it's sort of religious to me. I mean, it's like a special place. I'm not a set person in one religion but nature does make me feel that there is a God when I see how things are created and what is happening.

The professors were no Philistines. They too spoke with a sense of awe in response to nature. In contrast, however, the professors seemed to prefer metaphysical agnosticism. Note in the example below how the professor quickly retreats to positivism. Positivism has traditionally eschewed the metaphysical, thus this retreat effectively shields the professor from having to deal with such issues.

Professor: You can see connections in nature, especially biological connections... I don't get into the spirituality of it but when you see the biological connections, its amazing how we got here on the earth... I don't really deal with a spiritual force... I can't deal with things I can't measure and observe.

The professors' willingness to entertain religious or metaphysical ideas varied, but none embraced such ideas the way many of their students did.

In sum, the comparison of transcripts shows only occasional similarities between professors and students. There was similarity among professors and dissimilarity between the professors as a group and their students who amongst themselves were quite dissimilar.

Discussion: I hesitate to use the term scientific worldview because as I have argued elsewhere (Cobern, 1991c), this usage implies that all scientists share the same worldview. While scientists have similar views about science, it is not the case that all or even most scientists share the same worldview. Even within the small group of scientists in this study, differences are evident. Nevertheless, in common parlance people would say that these professors clearly have a scientific worldview. They freely, frequently, and naturally integrated science into their conversation. They spoke knowledgeably about science and spoke with enthusiasm. In contrast, these observations apply to few of the students. Some students simply did not speak of science leading one to conclude that science instruction has had little impact on their thinking. Others at times spoke of science and did so accurately and with enthusiasm. Whether one would say these students had a scientific worldview depends on which section of their transcripts one attended to. In other words, students

who spoke about science usually did not speak consistently about science.

The comparison of students and professors can be summed up with the phrase, depth versus breadth. The scientists focused on science and talked at length using ideas from science. The students spoke only intermittently about science, and some not at all. Student conversation exhibited a much greater breadth of ideas. They spoke of art and beauty, religion, emotions, resources and conservation, and of personal experiences. It is not surprising that a biologist without any prompting would voluntarily choose to speak of nature in scientific terms. Nevertheless, when laid side by side the difference between the students' and the professors' views of nature is striking. Two points come to mind. The comparison of transcripts provides cause for rethinking definitions of scientific literacy. Scientific literacy has often been thought of as a matter of having a particular attitude coupled with a set of acceptable scientific concepts that can be demonstrated on a test. By this definition these students must be considered scientifically literate, for after all, they had passed college level science courses taught by highly qualified science professors and genuinely enjoyed the experience.

However, a professional person of science, knowing nothing about the students, but happening to overhear their conversation about the natural world, would be much less sanguine. The eavesdropper would hear little integration of the knowledge the students purportedly mastered in their science courses. This leads to a different view of scientific literacy. Scientific literacy means that scientific concepts have been integrated into one's basic understanding of the natural world and are naturally used by that person, along with other concepts, in discussions about, and related to, nature (see McCormack & Yager, 1991; O'Neill, 1992; Rutherford, 1992). By this definition one has cause for concern about the literacy level of this particular group of students - especially knowing that this group had successfully completed several college level science courses.

The literature in science education suggests that the profession accepts the first definition for scientific literacy concomitantly assuming that the integration of the second definition will arise as a matter of course (Fensham, 1987). This is perhaps an overly optimistic assumption. At the start, it was noted that scientific knowledge and practice needs to be interpreted within specific social and cultural contexts (Shymansky & Kyle, 1991). In the transcripts of the biology professors and their students, we have an indication that student and professor bring different cognitive cultural contexts to the classroom. The professors' context is one focused on science. Yes, there are other elements such as aesthetics, but the focus is clearly science. The students bring a context with little focus but a

breadth ranging from science to religion. If these professors are typical of science teachers in general, and if we accept that a teachers' instruction is grounded in his or her semiotic interpretation of science (see Figure 1), then one would expect that the view of nature typical to science instruction is one quite different from the view of many students. If student learning is also a semiotic interpretation, then it should come as no surprise that many students do not share their teachers' view of nature, even after completing several college science courses.

Summary: I am cautious about claiming too much. We are still examining the data from the two studies. We have not actually looked at what happens in classrooms, at how the various perspectives of students and teacher may clash or be mutually supportive. In this study, the professors greater articulation of ideas was expected. That there were differences among the students was not unexpected. What is striking is the similarity of professors' views in contrast to the collectively different views held by their students. There are substantial differences between students and teachers that can be summed by the comment I made earlier: depth versus breadth. One might say that the professors had an epistemological orientation with its focus in science. The students had a coherence orientation. Theirs' was a more horizontally oriented point of view involving the relationships among various and different ideas. They lacked a focus on science, but then it is not likely that they were ever encouraged by either science teachers or curricula to reflect on how science relates to the many other endeavors of humanity. In all fairness to the biology professors, they were teaching advanced level professional courses and thus a narrow focus on science would be justified. The contrast between students and professors is more indicative of learning experiences in science from elementary grades through high school.

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