Defining "Science" in a Multicultural World: Implications for Science Education

WILLIAM W. COBERN
Joint Appointment, Departments of Teaching, Learning & Leadership; and Science Studies, Western Michigan University, Kalamazoo, MI, USA

CATHLEEN C. LOVING
Department of Educational Curriculum and Instruction, Texas A&M University, College Station, TX, USA

Received 27 July 1998; revised 10 November 1999; accepted 10 January 2000

ABSTRACT: In today's schools there are often competing accounts of natural phenomena, especially when schools are located in multicultural communities. There are also competing claims about what counts as science. This article examines the definition of science put forward from multicultural perspectives in contrast to a universalist perspective on science; that is, the Standard Account. The article argues that good science explanations will always be universal even if indigenous knowledge is incorporated as scientific knowledge. What works best is still of interest to most, and although one may hate to use the word hegemony, Western science would co-opt and dominate indigenous knowledge if it were incorporated as science. Therefore, indigenous knowledge is better off as a different kind of knowledge that can be valued for its own merits, play a vital role in science education, and maintain a position of independence from which it can critique the practices of science and the Standard Account. © 2000 John Wiley & Sons, Inc. *Sci Ed* **85:**50–67, 2001.

INTRODUCTION

Is science universal? Only recently has this question been given any serious consideration at all. In the tradition of science as practiced in the West for the past 300 years, and in the tradition of school science, the answer has been, "Of course science is universal." As Richard Dawkins likes to put it, there are no epistemological relativists at 30,000 feet. But today some will say, "Not so fast!" Dawkins offers a brute definition of universality completely devoid of any nuance of understanding and equally devoid of relevance to the question at hand. No one disputes that without an airplane of fairly conventional description, a person at 30,000 feet is in serious trouble. The question of universality does not arise over the phenomena of falling. The question of universality arises over the fashion of the propositions given to account for the phenomena of falling, the fashion of the

Correspondence to: William W. Cobern; e-mail: bill.cobern@wmich.edu

discourse through which we communicate our thoughts about the phenomena, and the values we attach to the phenomena itself and the various ways we have of understanding and accounting for the phenomena—including the account offered by a standard scientific description.

In today’s schools there are often competing accounts of natural phenomena, especially when schools are located in multicultural communities. There are also competing claims about what counts as science, such as the Snively and Corsiglia article in this issue. The purpose of our article is to examine the definition of science put forward from multicultural perspectives in contrast to a universalist perspective on science, that is, the Standard Account. We will argue that good science explanations will always be universal even if we do incorporate indigenous knowledge as scientific and broaden what is taught as science. What works best is still of interest to most, and although we hate to use the word hegemony, Western science would co-opt and dominate indigenous knowledge if it were incorporated as science. Therefore, indigenous knowledge is better off as a different kind of knowledge that can be valued for its own merits, play a vital role in science education, and maintain a position of independence from which it can critique the practices of science and the Standard Account.

MULTICULTURAL PERSPECTIVES ON SCIENCE

If there are different ways of accounting for a phenomena of nature then it is possible that some people will reject some of these accounts—including the account offered by Western science—and accept others. Gibson (1996) tells of a time when she was working at a rainforest scientific station on a South Pacific Island and a conversation she had with an indigenous Islander. The Islander commented that Westerners only think they know why the ocean rises and falls on a regular basis. They think it has to do with the moon. They are wrong. The ocean rises and falls as the great sea turtles leave and return to their homes in the sand. The ocean falls as the water rushes into the empty nest. The ocean rises as the water is forced out by the returning turtles. Is this Islander scientific because he has accurate knowledge of the ocean tides that affect his island? Is he unscientific because his explanation for tidal action is scientifically inappropriate? Is science universal because the standard scientific account for tidal action applies to all local occurrences of tidal phenomena? Or, does one grant the obvious brute factuality of actual phenomenon but reject universalist claims for standard scientific accounts of actual phenomenon? Matthews well states the universalist perspective of the Standard Account:

> Just as volcanic eruptions are indifferent to the race or sex of those in the vicinity, and lava kills whites, blacks, men, women, believers, nonbelievers, equally, so also the science of lava flows will be the same for all. For the universalist, our science of volcanoes is assuredly a human construction with negotiated rules of evidence and justification, but it is the behavior of volcanoes that finally judges the adequacy of our vulcanology, not the reverse.” (Matthews, 1994, p. 182)

The undeterred critic, however, will still ask: Though the phenomenon are experientially universal, can’t one argue that scientific accounts are not universal since such accounts are not universally accepted?

The resolution of such questions hinges on the definition of science, including the concept of universality, and this resolution is of considerable importance for both educators and the public at large. When a discipline earns the title “science” it “acquires the authority to promulgate truthful and reliable knowledge, control over education and credentials, access to money and manpower, and the kind of political clout that comes from possessing knowledge that is essential yet esoteric" (Fuller, 1988, p. 177). In science education, the definition of science is a *de facto* gatekeeping device for what can be included in a school science curriculum and what cannot. A very large amount of money, for example, has been spent in the United States on litigating the question of whether or not "creation science" can be properly included as an aspect of school science (Nelkin, 1983; Overton, 1983). Moreover, if science is deemed universal it not only displaces scientific pretenders such as creation science, it also displaces any local knowledge that conflicts with it. Kawagley, Norris-Tull, and Norris-Tull (1998, p. 134) argue that "such a narrow view of science not only diminishes the legitimacy of knowledge derived through generations of naturalistic observation and insight, it simultaneously devalues those cultures which traditionally rely heavily on naturalistic observation and insight." The record is fairly clear. Around the globe where science is taught, it is taught at the expense of indigenous knowledge and this precipitates charges of epistemological hegemony and cultural imperialism.

People feel passionately about these issues. The passions in the academy have run so high that the controversies have been dubbed the "Science Wars" (Nature, 1997). At school levels, the struggle is over multicultural approaches to science and science education within multicultural situations. Actions taken are at times extreme. In 1987, the Portland Oregon School District published the *African-American Baseline Essays*, a set of six revisionist essays providing resource materials and references for teachers on the knowledge and contributions of Africans and African-Americans. The science baseline essay, written by Hunter Havelin Adams (1990), has serious problems, but it is widely distributed because of the current pressure on school districts to incorporate multicultural material into the classroom, coupled with the dearth of this kind of material. Hundreds of copies of the *Baseline Essays* have been sent to school districts across the country and have been adopted or are being seriously considered by school districts as diverse as Fort Lauderdale, Detroit, Milwaukee, Atlanta, Chicago, Prince Georges County, MD, and Washington, DC. Even more widely distributed is its predecessor, *Blacks in Science: Ancient and Modern*, edited by Ivan Van Sertima (1984). Vine DeLoria, who is involved with Indian science education through the American Indian Science and Engineering Society (AISES) has recently published a book entitled *Red Earth, White Lies: Native Americans and the Myth of Scientific Facts* (DeLoria, 1995). These supplements on multicultural science, expressly intended to "raise the self-esteem" of students, adopt a triumphalist approach to the material. That is, they present the achievements and the beliefs of the group described as superior and anticipatory to the achievements and beliefs of modern *Western* science. Thus, the Dogon of Mali supposedly studied Sirius B, which is invisible to the naked eye, hundreds of years ago. The Egyptians foreshadowed the Theory of Evolution thousands of years ago; the Egyptians also anticipated many of the philosophical aspects of quantum theory (Adams, p. 21), and they knew the particle/wave nature of light (p. 26).

The *Baseline Essays* and similar publications represent a radical revisionist historiography of science and culture. There are other examples of multicultural materials for science education that are far less controversial. Books such as Robertta Barba's (1995) *Science in the Multicultural Classroom: A Guide to Teaching and Learning* and the Addison Wesley (1993) teacher's guide, *Multiculturalism in Mathematics, Science, and Technology: Readings and Activities,* bring culture into the science classroom for pedagogical purposes without rewriting history. The nature of science implicit in these books, however, represents a subtle change from standard accounts. Looking elsewhere, the question of how *science* is to be defined is brought into clear relief (e.g., Kawagley & Barnhardt, 1998; Kawagley, Norris-Tull, & Norris-Tull, 1998; Snively & Corsiglia, 2001) With specific reference to First Nations people in Canada and the Yupiaq people of Alaska, one finds that indigenous knowledge is reclassified as science—but not *science* according to the Standard Account, and therein lies the controversy.

MULTIPLE CULTURE-BASED SCIENCES?

The Standard Account of science can be called *“Western”* given its historic origins in Ancient Greek and European culture. Speculative thought about nature, natural philosophy, and later what became known simply as *“science”* always engaged Western culture. The Western experience with science has been a long one and, in a sense, Western culture and science have matured in consort, but not without trials. “There has been, on the one hand, a disintegrating effect on traditional values and forms of representation, and, on the other hand, a progressive integration into the dominant culture . . . of the scientific mentality—the values, content of knowledge and patterns of action which underlie scientific practice and are formed by it” (Ladrière, 1977, p. 12). This disintegrating effect appears to have been recognized by Charles Darwin, who late in life lamented,

> I have said that in one respect my mind has changed during the last twenty or thirty years. Up to the age of thirty, or beyond it, poetry of many kinds . . . gave me great pleasure, and even as a schoolboy I took intense delight in Shakespeare . . . I have also said that formerly pictures gave me considerable, and music very great, delight. But now for many years I cannot endure to read a line of poetry: I have tried to read Shakespeare, and found it so intolerably dull that it nauseated me. I have also almost lost my taste for pictures or music . . . I retain some taste for fine scenery, but it does not cause me the exquisite delight which it formerly did . . . My mind seems to have become a kind of machine for grinding general laws out of large collections of facts . . . (quoted in Owens, 1983, p. 38)

And, of course, the European Romantic poets echoed this lament (see Barber, 1963).

Moreover, Europe was an expansionist culture, and European exploration, conquest, and colonization of lands beyond Europe brought Western science to those lands and their inhabitants. In these parts of the world where Western science is experienced as a relatively new phenomena, the interaction of science “with culture has taken a more violent form and the disintegrating effects have been much more sharply experienced” (Ladrière, 1977, p. 14). Indeed, colonial education designed for indigenous peoples used science as the tool of choice to modernize and supplant indigenous culture. In the words of one colonialist: “A literate nation is provided with the means for substituting scientific explanations of everyday events—such as death, disease, and disaster—for the supernatural, non-scientific explanations which prevail in developing societies . . .” (Lord, 1958, p. 340). A more reflective colonial teacher remarked, “In common with so many others, I used to think that we could get rid of Bantu ‘stupidities’ by suitable talks on natural science, hygiene, etc., as if the natural sciences could subvert their traditional lore or their philosophy” (Tempels, 1959, p. 29). The point is, the West judged the rest of the world by its own measures of choice, Western science and Western technology, and used education to enforce change on those societies found deficient. According to Adas (1989, p. 4) European “perceptions of the material superiority of their own cultures, particularly as manifested in scientific thought and technological innovation, shaped their attitudes toward and interaction with peoples they encountered overseas.” Why? Because:

> In the late eighteenth and nineteenth centuries, most European thinkers concluded that the unprecedented control over nature made possible by Western science and technology

> proved that European modes of thought and social organization corresponded much more closely to the underlying realities of the universe than did those of any other people or society, past or present. (Adas, 1989, p. 7)

Western scientists did have scientific interests in the rest of the world. Many areas of the globe became field sites for the practice of Western science by Western scientists (Basalla, 1967). Darwin's voyage on the Beagle is surely the best known example of Western scientific development derived from non-European field work. When scientists occasionally took note of indigenous knowledge of nature, that knowledge was distinctively labeled *ethnoscience* (e.g., Behrens, 1989; Berlin, 1972; Boster & Johnson, 1989)—never simply *science.* This is not to say that such indigenous knowledge was regarded as without value. There is a long tradition of Western science finding value in indigenous knowledge, especially as an aid to pharmaceutical discovery (Linden, 1991). But, finding value in indigenous knowledge is not the same as conferring the title *"science"* and admitting indigenous knowledge of nature to the Standard Account.

In the 1990s, non-Western peoples and some scholars within the West began to formally and overtly resist this imperial Western attitude toward indigenous knowledge of nature. This movement was abetted by the program for the social study of science, founded in the 1970s at Edinburgh (Bloor & Barnes, 1996), which argued that all science is socially contingent and culturally embedded. New epistemological perspectives such as multiculturalism (Stanley & Brickhouse, 1994), post-colonialism (McKinley, 1997), and postmodernism (Lyotard, 1995) rose to challenge the conventional Western wisdom on the relationship between science and culture and the Standard Account itself. In education, Hodson (1993, p. 686) maintained that science curricula often "portray science as located within, and exclusively derived from, a western cultural context. The implicit curriculum message is that the *only* science is western science . . ." Dr. Thom Alcoze is Native American and a forestry professor at Northern Arizona University. In a taped interview for a science teacher development project (Smithsonian Institution, 1996b) he poignantly presented a different perspective on science:

> Science is often thought of [pause] America has science. Mainstream America has science. And if you are a minority culture in this country you don't have science. We started looking for Indian science where science is expressed in Indian tradition. And found it with plants, starting off. Medicines. And of course the stereotype is well Indian medicine is just superstition and mumbo-jumbo, sleight of hand, and basically it's a witch doctor kind of thing [pause] a stereotype. A lot of strange noises and dancin' and singin' and a lot of shakin' but that's all it is [pause] superstitious. It's not real. What we found out when we looked for facts, we found that even today in modern America there are over 200 medicines in the pharmacopoeia that we use that have direct origins in Native American medical practice. Yes, in fact Indian people did have science. They were using science all the time. They weren't using scientific terminology. They did not publish in scientific journals [pause] that's kind of facetious at that time. But the issue of science then started to be redefined in my definition of what science is all about when we started to see that science is just another word for nature.

Dr. Alcoze's last sentence is of critical importance. He says, "science is just another word for nature" and, therefore, American Indians being greatly knowledgeable about nature had scientific knowledge of their own. This idea is further developed in Kawagley et al. (1998, p. 134): "We contend that no single origin for science exists; that science has a plurality of origins and a plurality of practices." They contend "that there is no one way to do or think about science" (p. 139). As their case in point, they contend that Yupiaq culture in southwestern Alaska holds "a body of scientific knowledge and epistemology that differs from that of Western science" (p. 133):

> Much of Yupiaq scientific knowledge is manifested most clearly in their technology. One may argue that technology is not science. However, technology does not spring from a void. To invent technological devices, scientific observations and experimentation must be conducted. Yupiaq inventions, which include the kayak, river fish traps . . . represent technology that could not have been developed without extensive scientific study of the flow of currents in rivers, the ebb and flow of tides in bays, and the feeding, resting, and migratory habits of fish, mammals, and birds. (Kawagley et al., 1998, p. 136)

"Science" from this perspective refers to descriptive knowledge of nature developed through experience with nature. The definition of science used here is consistent with Ogawa (1995, p. 588) who refers to science simply as "a *rational* perceiving of reality." From this definition, Ogawa (1995) argues for the existence of many different legitimate sciences.

The knowledge described is from a domain of knowledge that Snively and Corsiglia (2001) call traditional ecological knowledge (TEK). It is the descriptive ecological knowledge about nature that First Nations peoples in Canada and Native Americans in the United States have acquired through long years of experience with their natural environment, and which has been vital to their survival. Snively and Corsiglia (2001) show that this knowledge can be quite insightful and has much to offer Western science. For example, they tell the story of a Nisga'a fisherman in British Columbia who noticed that the Dungeness crabs he typically harvested were exhibiting strange behavior patterns. The crabs were "marching past the dock at the mouth of the Nass River, rather than staying in the deep water of Alice Arm" (Snively & Corsiglia, 2001, p. 19). He grew concerned about possible industrial pollution of the Alice Arm waters from a nearby molybdenum mine and later his concerns were shown to be well-founded. Given the life and practice of the Nisga'a this intuition should come as no surprise:

> Among the Nisga'a, and among other aboriginal peoples, formal observation, recollection, and consideration of extraordinary natural events is taken seriously. Every spring members of some Nisga'a families still walk their salmon stream to ensure spawning channels are clear of debris and that salmon are not obstructed in their ascent to spawning grounds. In the course of such inspection trips, Nisga'a observers traditionally use all of their senses and pay attention to important variables: what plants are in bloom, what birds are active, when specific animals are migrating and where, and so forth. In this way, traditional communities have a highly developed capacity for building up a collective data base. Any deviations from past patterns are important and noted. (Corsiglia & Snively, 2001 p. 19)

Similar accounts were obtained for people living traditional lives in many other regions of the world from Australia to Africa (see Warren, 1991, 1997).

MULTICULTURAL SCIENCE IN THE CLASSROOM

The reasons for including such examples of knowledge as part of the Standard Account, or the reasons for expanding the definition of science under the Standard Account, have to do with education. Proponents of a multiplicity view of science argue that this will better serve the needs of students coming from diverse cultural backgrounds and will help to change the culturally corrosive effect that Western science has had on non-Western cultures. "The Harvard-Smithsonian Video Case Studies in Science Education" (Smithsonian Institution, 1996a, 1996b) project on classroom science provides a glimpse of how this multicultural perspective on science can play out in a science classroom. The project produced videotape case studies of teachers. Each tape shows vignettes of a teacher teaching science interspersed with interview segments with the teacher and a science education expert. One of the case studies was done at an elementary school in Flagstaff, Arizona where the students come from American Indian and non-Indian families. Donna is a fifth grade teacher and she has been teaching a unit on ecology. She also has drawn in her Native American students by collecting information on Indian culture. This information is publicly displayed on a large poster board in the classroom (see Figure 1).

Pointing to the poster board, the teacher speaks to her students.

> Donna: We were talking earlier in here about looking at different cultures and finding ideas from cultures that might help us understand science better. Now, some of the traditional Native American views about nature are on this chart. Can you find one [Native American view] that helps us to understand this cycle of decompositions? (Smithsonian Institution, 1996b)

At this point a number of students raise hands. The teacher calls on them to speak and she asks each student to explain the relationship of the Native American viewpoint to decomposition. Later, Donna is asked in an interview about the purpose of such activities.

> Donna: My goal would be that all children would feel that they have a very important heritage. No matter what heritage they come from. And to be a scientist doesn't mean that you have to be any particular race or any particular gender or from any particular culture but that all people have contributed to the body of knowledge which we call science. (Smithsonian Institution, 1996b)

In this vignette, Donna has set a very nice stage with her Native American poster about views of nature. From here she can go on to have her class study what science has learned about ecological cycles, balances of nature, decomposition, etc. Loving (1998) and Cobern (1995b) offer similar views on using local culture to promote science learning.

One would only hope that along the way reference might be made back to the poster to see if science supports, ignores, or rejects ideas from one's culture and what evidence there is to support that. In Donna's case, the controversial questions are about her meaning for the word "science" and if she will lead her students to understand that there are different legitimate ways of thinking about nature? "Nature is viewed as sacred" is one such legitimate way, but it is not the way of science. Thus, we would want to know if Donna intends to help her students cognitively construct two different, though complementary, explana-

- Nature is viewed as sacred.
- Humans are part of the web of life.
- Humans should live in harmony with nature.
- The entire world is viewed as being alive.
- Technology should be low impact.

Figure 1. Native American views about nature (Smithsonian Institution, 1996b).

tions for the same phenomena? Or, will the students learn the multiplicity view that all of this simply represents different forms of science?

THE UNIVERSALITY OF SCIENCE

As much as we support science teaching that is both informed by culture and sensitive to culture, the issues raised by TEK and multicultural perspectives on science must not be accepted uncritically. We say this not in defense of science and the Standard Account, but because we think that science has shown itself sufficiently useful and remarkable to humanity so that there will be no withdrawal of science from modern life. And, it is arguable that science would suffer little harm if, for the purposes of curriculum, TEK and similar domains of knowledge were declared *scientific* tomorrow. In contrast, such an action would actually be counterproductive with respect to the concerns people have about indigenous knowledge being shut out of science by the Standard Account. Before developing that thought, however, we clarify our meaning of the Standard Account and the case for universality.

Defining the Standard Account

Loving's (1991) *Scientific Theory Profile* gives a good indication of the breadth of philosophical views on the nature of science. Philosophers of science run the gamut from rationalist to naturalist, anti-realist to realist, and the many combinations within these ranges. Within the philosophy of science and scholarship on the nature of science resides the important question of demarcation. How can science be distinguished from other intellectual domains? How does science differ from (say) historiography or theology or philosophy? According to Gieryn, Bevins, and Zehr (1985, p. 392) the goals of demarcation are the "(1) differentiation of a valued commodity uniquely provided by science, and (2) exclusion of pseudoscientists . . ." and these goals "are important for scientists' establishment of a professional monopoly over the market for knowledge about nature" (also see Gieryn, 1983; Smith & Scharmann, 1999). The demarcation of science from other disciplines, however, is not easily accomplished. Laudan (1983, pp. 8–9) argues that:

> philosophers have been regarded as the gatekeepers to the scientific estate. They are the ones who are supposed to be able to tell the difference between real science and pseudo-science. . . . Nonetheless, it seems pretty clear to many of us . . . that philosophy has largely failed to deliver the relevant goods. Whatever the specific strengths and deficiencies of certain well-known efforts at demarcation . . . it can be said fairly uncontroversially that there is no demarcation line between science and non-science, or between science and pseudo-science, which would win assent from a majority of philosophers.

Though we do not wish to minimize the philosophical complexity of the issue to which Laudan refers, nor are we immune to the ideological influences upon the Standard Account (Hesse, 1980), there is a pragmatic view to science broadly acceptable in the scientific community and described in accounts by scientists themselves, such as biologist Frederick Grinnell (1987) and physicist A. F. Chalmers (1982). In addition, science educators (Driver, Leach, Millar, & Scott, 1996) who thoughtfully examined the range of philosophical, historical, and sociological views of science, were able to arrive at critical areas of consensus and were helpful in our Standard Account. The following is what we understand that definition of the Standard Account of science to be. In providing this definition we have kept in mind Laudan's (1996, p. 24) point that what "we need to provide is a way of distinguishing reliable knowledge claims from unreliable ones."

1.0 *Science is a naturalistic, material explanatory system used to account for natural phenomena that ideally must be objectively and empirically testable.*
1.1 Science is about *natural phenomena.*

It is not about the things that humans construct, such as economic systems, nor is it about spiritual phenomena. Here we concur that TEK is about natural phenomena.

1.2 The explanations that science offers are *naturalistic* and *material.*

It follows from point 1.1 that scientific explanations are not about the spiritual, emotional, economic, aesthetic, and social aspects of human experience. Snively and Corsiglia (2001) recognize that with respect to TEK this aspect of the Standard Account poses a problem, even though TEK is about natural phenomena. They note that many scientists refuse to recognize TEK as science "because of its spiritual base, which they regard as superstitious and fatalistic" (p. 23). In response, they argue that "spiritual explanations often incorporate important ecology, conservation, and sustainable development strategies" (p. 30); but nevertheless, they still assert that "the spiritual acquisition and explanation of TEK is a fundamental component and must be promoted if the knowledge system is to survive" (Johnson, 1992 quoted in Snively & Corsiglia, 2001, p. 23).

1.3 Science explanations are *empirically testable* (at least in principle) against natural phenomena (the test for empirical consistency) or against other scientific explanations of natural phenomena (the test for theoretical consistency).

Science involves collecting data (i.e., evidence) and a scientific explanation must be able to account for this data. Alternatively, science involves the testing of proposed explanations against data (Driver et al. 1996, p. 43). This concept is nicely captured by Duschl in an interview where he is commenting on the activities of some first graders. The first grade class is experimenting with sound. The children have some ideas about sound and they test some of these ideas using rubber bands stretched over geoboard pegs. About this episode, Duschl remarks:

> When kids are given the same phenomena to observe, they see very different things. Their personal interpretations of the ideas are very different. And when we listen to the children in circle you can hear this and see it. This is an opportunity to get this consensus that we want, to get some discussion because the scientific ideas just aren't any ideas. They are ideas grounded in evidence. (Smithsonian Institution, 1996a)

Duschl tells us that "the scientific ideas just aren't any ideas." They are tested ideas. They are tested either in the *physical* world following from point 1.2, or they are tested for theoretical consistency with other scientific explanations, which in turn were tested in the physical world.

Moreover, scientific testing strives to be *objective.* In recent years this value in science has been derided as "objectivism . . . a universal, value-free process" (Stanley & Brickhouse, 1994, p. 389; also see Guba & Lincoln, 1989). Perhaps some people have overextended the concept of objectivity. In our view of the Standard Account, objectivity refers to the goal that experimental outcomes not be prejudged nor unreasonably constrained by prior belief, that data is collected fairly and accurately, and that research methods are executed with fidelity.

Is it possible that TEK is *tested* knowledge? Borrowing a phrase form Sagan (1996, p. 251), Kawagley et al. (1998, p. 137) maintain that "Yupiaq traditional knowledge reflects an understanding of the natural world based on a 'massive set of scientific experiments continuing over generations.'" No one would doubt that the Yupiaq, along with every other group of people that ever lived, have and continue to engage in "trial and error" experimentation. People try different shampoos until they find the one the like best, but few would consider such "experimentation" scientific. It is not scientific, but it is an effective and valuable process. Similarly, the building up of traditional knowledge through trial and error interactions with nature has produced important knowledge. But, it lacks the formal, controlled features of scientific experimentation.

1.4 Science is an explanatory *system*—it is more than a descriptive *ad hoc* accounting of natural phenomena.

Science seeks to parsimoniously explain how things work, invoking only natural causes, and these explanations are woven into a system of *theoretical* thought. Theories, however, are typically underdetermined; that is, they go beyond the available data and are therefore conjectural. Scientists chose between competing theories based on criteria such as accuracy of prediction, internal consistency and data consistency, breadth of scope (the more encompassing the theory, the more it is valued), simplicity, and fruitfulness—all based, however, on human judgment (Driver et al., 1996). To this aspect of the Standard Account, the sociology of science adds that human judgment does not exist in a vacuum. It exists and is exercised within the context of social and cultural life. There is an inherently social aspect to all knowledge construction. Thus, for example, to understand how Darwin came to his formulation of evolution it is not sufficient to know about the voyage of the Beagle, his various observations, his knowledge of domestic breeding practices, and the like. One must also take into account the cultural environment in which Darwin lived (Cobern, 1995a, 2000; Desmond & Moore, 1991).

Moreover, it must be noted that scientific explanation (point 1.2) and scientific theory (point 1.4) represent two complementary levels of scientific knowledge (alternatively, the difference between what students think of as "description" and "explanation" in the theoretical scientific sense—see Horwood, 1988; Matthews, 1994). The first level is strongly related to direct human experience. Thus, for example, the location of salmon at any one time of the year can be explained in terms of the salmon's lifecycle, where evidence relating to locality and lifecycle are both directly observable. This explanation has considerable credibility regardless of cultural variation. In contrast, credibility at the second level is much more culturally dependent. At the second level, scientific theory would further explain that "lifecycle" can be viewed as an idealized pattern of sequenced events that is applicable across a great many organisms. Here credibility depends on how accustomed a people are to abstract scientific theorizing. In a different culture, people would find it more plausible to explain "lifecycle" as the purposeful course of life uniquely belonging to each creature. Horton (1994) has demonstrated that much of traditional African thought at the lower level does not differ substantially from scientific explanation. The significant differences are at the secondary level with the "webs of significance" (Geertz, 1973) that give meaning to those first level explanations. Similarly, here is the fundamental problem with taking TEK as science—TEK is embedded in a spiritual system of meaning that cannot easily be ignored, and should not be ignored.

2.0 *The Standard Account of science is grounded in metaphysical commitments about the way the world "really is"* (e.g., see Burtt, 1967; Cobern, 1991, 1995b).

These commitments take the form of necessary (or first order) presuppositions. They are not descriptive of what science is, but what science presupposes about nature. By themselves these necessary presuppositions are probably not sufficient motivation for any individual to be involved with science, hence any individual scientist or science teacher likely will have augmented these necessary presuppositions with other (secondary) presuppositions that are personally necessary. Our focus, however, is on the metaphysical minimum for science.

2.1 Science presupposes the possibility of knowledge about nature.

Realists view this as *actual* knowledge—human thinking holds the potential for recognizing and understanding the actual order and causality inherent in the phenomena of nature. Idealists view this as *instrumental* knowledge—human thinking holds the potential for constructing viable understanding about the instrumental order and causality in the experience of natural phenomena. Roger Penrose and Stephen Hawking, respectively, are exemplars of the two positions (Hawking & Penrose, 1996). Closely linked to the possibility of knowledge are the presuppositions of order and causality.

2.2 Science presupposes that there is *order* in nature.

The fact that the orbit of the earth can be represented as a mathematical equation or that tidal action can be estimated within predictable limits of accuracy is evidence of order. Realists view this order as *actual order*—there *is* order in nature. Idealists view this as *instrumental order*—human experience with nature is amenable to ordered thinking about experience with nature. Historically, presupposed order in nature was profoundly important to the development of science in Europe. Gernet (1993–1994), following the pioneering work of Needham (1969), notes the crippling effect the lack of this presupposition had on the development of Chinese science.

2.3 Science presupposes *causation* in nature (Collingwood, 1940).

For example, rain is causally linked with factors such as air temperature and humidity. Given enough water vapor in the atmosphere and the right air temperature, it is going to rain. Realists view this causation as *actual causation*—cause and effect are inherent attributes of nature. Idealists view this as *instrumental causation*—causal thinking is compatible with the human experience with nature.

3.0 *Nevertheless, what ultimately qualifies as science is determined by consensus within the scientific community.*

Thus, simply offering an idea which fits all these parameters will still not be science until judged so by the community of science. As we noted above, the problem is that there is no perfect account of science that clearly represents all of science, past and present, and just as clearly eliminates all endeavors that scientists do not consider to be science. In the final analysis a human judgment must be made. However, the community of scientists is a community that requires that scientific knowledge be made public and withstand public scrutiny and testing. Thus, any conspiracy to include or exclude any domain of thought is unlikely to succeed in the long run.

The Universality of Science

Much of the multicultural literature on science seems to be saying that the problem with the Standard Account is that it is taken to be the only account of science — it is an exclusive and universally appropriate account. But we wonder if this really is the bone of contention among multiculturalists? Is it the alleged *universality* of science or is it the intellectual exclusiveness of science according to the Standard Account? We ask this because the post-colonialist arguments rejecting the universality of science seem to be arguments more about the exclusivity of science. It seems to us that even if the definition of science were broadened to include what is now excluded, one would still have a “universal” science. Indeed, if there is no universal concept of science then how can anything be either included or excluded as science?

It can be instructive to consider a different type of example altogether. Around the globe “football” is a widely recognized sporting game. We in America have a game called “football,” but it is significantly different from what the rest of the world calls football. In fact, the rest of the world, for the sake of clarity, refers to the American game as “American football” to distinguish it from REAL football. With enough political agitation and economic clout those of us Americans who resent this form of marginalization could possibly get the rest of the world to broaden its definition of “football.” The term “football” still is universal (we now all agree that the game of football includes the varieties played in the United States and elsewhere), but it now has a new meaning that is general enough to include what many previously took to be two rather distinct games. Undoubtedly there are other games played with a ball and the feet. If the proponents of these games agitate as successfully as did the American footballers, where will the process end? In our opinion, this is anti-reductionism made absurd and the end result is that everyone loses. Diversity is lost. Meaning is lost. Communication is lost.

We thus conclude that the real difficulty multiculturalists have with the Standard Account is not its claim to universality, but its exclusiveness. Though technically difficult to accomplish, conceptually the Standard Account could be broadened by simply getting a consensus in the science community for the rewriting of the definition of science in a more inclusive form. Then one could have “Maori science” or “First Nations science,” (or for that matter, “Christian science,” “Islamic science,” etc.), just as “football” could be broadened to include “American” football. We could be even more inclusive by simply taking science to be knowledge of nature — but one needs to reconsider why would anyone want to do any of these things? Early in this article we quoted from Kawagley et al. (1998, p. 134) on the relationship between the Standard Account and indigenous knowledge:

> such a narrow view of science not only diminishes the legitimacy of knowledge derived through generations of naturalistic observation and insight, it simultaneously devalues those cultures which traditionally rely heavily on naturalistic observation and insight.

We see in this statement that some people are troubled about the dominant intellectual position that modern Western science has come to hold in the public square. It is a position of dominance that tends to disenfranchise competitors. One way for competitors to regain that franchise is to oust Western science. Another way to regain access to the public square — and this is the approach many multiculturalists appear to be taking — is to get one's ideas included in the definition of the dominant player, in this case Western science or the Standard Account.

If such a thing were to ever happen it would be a pyrrhic victory for indigenous knowledge. The new additions to science (TEK or any other form of indigenous knowledge) would soon face serious negative consequences. They would first lose their distinctiveness as a form of thought as they became absorbed by the dominant discourse of science, that is, the Standard Account. They would lose because the new additions would inevitably be taken as mere "tokens" of cultural inclusiveness rather than as serious participants in the discourse of science. This tokenism would be reinforced by the inability of the new additions to compete where Western science is strongest—technical precision control, creative genius, and explanatory power. And, the new additions would lose by being co-opted into the cultural chauvinism scientism now holds in much of modern life. Snively and Corsiglia (2001) rightfully question where is the wisdom in science? As an incorporated part of science, that critique and challenge would be much more difficult to make.

THE PROBLEM OF SCIENTISM

The problem facing TEK and other forms of indigenous knowledge, as well as other domains of knowledge such as the arts and literature and religion, is the problem of scientism—the cultural hegemony science. The problem is not that science dominates at what it does best: the production of highly efficacious naturalistic understanding of natural phenomena. The problem is that too often science is used to dominate the public square as if all other discourses were of lesser value. This is a hierarchic view of knowledge with science placed at the epistemological pinnacle (see Figure 2).

For example, the National Academy of Science out of fear over religious incursions in school science issued this statement:

> In a nation whose people depend on scientific progress for their health, economic gains, and national security, it is of utmost importance that our students understand science as a system of study, so that by building on past achievements they can maintain the pace of scientific progress and ensure the continued emergence of results that can benefit mankind. (NAS, 1984, p. 6)

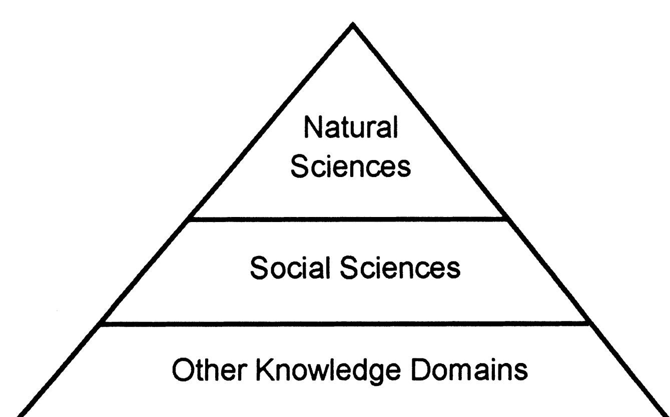

Figure 2. Epistemological pyramid.

More recently, the International Council of Scientific Unions (ICSU) endorsed a similar perspective in the "Proposed ICSU Programme on Capacity Building in Science" (ICSU, 1996). The document epigram equates "the global gap of well-being" with "the global imbalance of science and technology development." The ICSU intends to:

> demonstrate to the world that having the capacity to understand and use science is economically, socially, and culturally profitable. Indeed, the very habitability of the planet will depend on global popular consensus. As such, the spread of scientific culture, of scientific ways of thinking, and of knowledge is tied to the fate of humanity. (p. 1)

About these statements we can say, of course, few people question the productive role that science has played in the development of modern life, including medicine and contributions to good health. Nor will any deny the economic gains due to technical innovations grounded in science. But the relationship between science and technology is not nearly so straightforward as these statements from the science community suggest. These claims by the NAS and the ICSU, however, are vastly overstated and singularly one-sided. Good health, economic well-being, and national security all depend on many things, only one of which is science. Moreover, as important as science surely is it does not have an uncontested claim to be the most important of these many factors. Curiously, though the NAS and the ICSU appear eager to accept credit for good technological innovations, there is no parallel acceptance of technological disasters. If the science community wants credit for developing high yield grains that ease food shortages, how can the same community refuse credit for DDT's adverse consequences? Something is wrong with this portrayal of science (we might even say *betrayal* of science). Garrard and Wegierski (1991, p. 611) suggest an explanation:

> It can be argued that technology and scientific positivism constitute the dominant ideology of Western civilization today. Technology has indeed become, as Heidegger noted, the metaphysics of our age, a totalistic form of secular religion ultimately incompatible with the existence of rival, nontechnological assumptions, beliefs, or thought systems.

The problem for TEK—as well as for so many other domains of knowledge—is not the exclusivity of science as per the Standard Account, but the transmogrification of science as scientism in the public square.

EPISTEMOLOGICAL PLURALISM

When there is a gatekeeper and you persuade the gatekeeper to let you in, although you may have influenced the gatekeeper you have also conceded his legitimacy as gatekeeper. Similarly, getting TEK into the school curriculum *as* science does not address the fundamental problem that led to the devaluing of TEK and other forms of indigenous knowledge in the first place. The task for educators is to develop curricula that value knowledge in its many forms and from its many sources. Therefore, bringing TEK into the science classroom is an excellent thing to do. It offers students a chance to see how the practice of science can benefit from the insights of another domain of knowledge. It helps students see that some of the insights from science can be arrived at by other epistemological pathways. And, it helps students see what is unique about science—what science can do that other domains of knowledge cannot do.

We therefore reject positions of scientific and epistemological relativism. Not all thoughts are equal. Not all ways of thinking are parallel. But life is a complicated affair and the skillful navigation of life requires a diverse repertoire of thought and reason. What is essential for a suburbanite American to understand about nature will not be satisfactory for a Nisga'a fisherman living in a very different world. Thus, what we value is the best thinking for a given situation and the wisdom to change one's thinking when situations change. We advocate epistemological pluralism and the ability to wisely discriminate amongst competing claims. This last point is important because the issues of life typically cross epistemological categories. It is not always obvious in the public when a problem does or does not call for a scientific solution. Should the United States spend four billion dollars to build a Super Collider? The scientific answer is probably "yes" since the Collider would help make important advances in physics. But, America is not building the Super Collider because science was out bid by the competing discourse of politics and economics. In other situations we may find other domains of knowledge acting in consort with science. Snively and Corsiglia (2001) give a number of examples of ecologists and biologists profiting from the TEK of indigenous peoples. The Native American Forestry Program at Northern Arizona University (1997) provides another example where science and traditional knowledge work in consort.

In other situations, however, science rightly precipitates and influences cultural change. Consider the following situation. At a recent NARST session a researcher read the script of dialogue between an Australian Aborigine and a health care worker indicating totally different perspectives regarding the value and use of high-protein foods. The food is valued as nutrition, especially for children, in the West and valued as gifts in adult relationships to the Aborigines. The result of the latter perspective is continued high infant mortality for children under two years of age despite health care workers' careful use of Socratic methods to dignify the alternate views while educating the Aborigines. From the perspective of traditional Aboriginal life, that of a hunter/gatherer culture, the elevated social and political status of the elders makes their health critical to the success of the tribe. From that perspective they were correct to reject the science-based position. However, cultures cannot maintain a status quo in the face of environmental change and expect to survive. The fact that the researcher was involved with an education program for Aboriginal peoples indicates that the researcher knew this full well. Thus, in this case the possible cultural changes precipitated by science education regarding young children's need for high protein food are likely to be in the groups' long-term best interests.

The unfortunate fact of this last example is that the researcher represented the Aboriginal rationale for distributing the best food to important adults as equally *scientifically valid* as a distribution based on confirmed nutritional value and nutritional need at various stages of human physical development. But, if all explanations are mistakenly valorized as scientifically valid (and there is no attempt at understanding the best *scientific* explanations), we are reduced to relativism of the worst kind. Privileging "what knowledge is of most worth" in science class is *not* the same as denying the value of other forms of knowledge (Loving, 1997). What is at issue here is the learning of when scientific knowledge should be appropriated over other competing domains of knowledge because it is the best knowledge available for the particular situation.

CONCLUSION

Our position in this article is that science can be defined with sufficient clarity so as to maintain a coherent boundary for the practical purposes of school science curriculum development. That boundary excludes most forms of indigenous knowledge, if not all, just as it excludes art, history, economics, religion, and many other domains of knowledge.

Being exclusive, however, does not confer science with any privilege vis-à-vis other domains. Science is properly privileged only within its own domain for that is where its strength lies. When TEK and other forms of indigenous knowledge are devalued it is not because of the exclusive nature of the Standard Account of science. It is because someone is involved in the scientistic practice of extending scientific privilege from its proper domain in science and technology into other domains. The solution is to resist this scientistic practice by emphasizing throughout schooling the concept of epistemological pluralism, bearing in mind that pluralism:

> is not relativism . . . Pluralism is the civil engagement of our differences and disagreements about what is most importantly true. Against the monism that denies the variety of truth, against the relativism that denies the importance of truth, and against the nihilism that denies the existence of truth, we intend to nurture a pluralism that revives and sustains the conversation about what really matters, which is the truth. (First Things, 1995, p. 12)

Bearing *also* in mind that truth is never under the sole proprietorship of any single domain of knowledge — not even science.

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