Teaching Sciences: The Multicultural Question Revisited

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

ABSTRACT: We contend that science education should be multicultural. We do not believe a universalist view of science is either compatible with a multicultural approach or fully coherent as a foundation for the science curriculum. We begin by summarizing the case for a universalist approach to science education. We then show weaknesses of universalism in accounting for the following: 1. the limits of human cognitive capabilities in constraining what we can understand about nature; 2. a description of reality as a flux; 3. the disunity of science and the role of culturally different forms and social organization of research in shaping the cognitive content of the sciences. We argue that it would be valuable for students to understand the nature of the debates regarding multicultural and universalist perspectives on science. For example, what questions is contemporary molecular biology good at answering? What kinds of problems do other sciences solve? What historical conditions may explain why western sciences arose primarily out of Western European culture rather than elsewhere in the world? How do other belief systems (e.g., religion) interact with indigenous sciences, Chinese science, and Western science?

INTRODUCTION

Multiculturalism in science education has become an increasingly rich area of study as educators struggle to find answers to the question of how to teach science in a multicultural world. Many educators have focused their efforts on the question of what kind of science (Western modern science (WMS) and/or local “ethnic” science) to teach indigenous people whose worldviews are distinctly different from mainstream Western ones (e.g., Jegede, 1996; Ogawa, 1995.) Other educators have focused more on the question of how to teach WMS to indigenous people or to any student whose worldview differs significantly from that of WMS [a group of students Aikenhead and Jegede (forthcoming) argue are the majority]. Aikenhead (1996, 1997) argues that the task for students in this situation is that of “cultural border crossing.” The effective teacher in this situation is described as a culture broker. We have advocated the use of cross-cultural case studies as one way of helping students (Western and non-Western) understand cultural assumptions and influences that shape
science (Stanley & Brickhouse, 1994). Interestingly, this approach has also been advocated by Michael Matthews (1994) and Harvey Siegel (1997), both of whose views on universalism in science are very different from ours. More recently, Snively and Corsiglia (1998) have made their own recommendation that both indigenous knowledge (IK) and traditional ecological knowledge (TEK) be used in cross-cultural case studies in science education. Thus, the apparently simple recommendation for teaching cross-cultural case studies is supported by scholars with very different views of what science is. Siegel (1997) and Matthews (1994) advocate a universal view of science. Whereas we, like Snively and Corsiglia, hold a more relativist, contextual, and historicist view of science, although our views of science seem somewhat different from theirs.

The universalists argue that WMS provides a superior knowledge of the natural world as compared with premodern European thought or the various “folk thought,” “ethnoscience,” and other less worthy forms of knowledge held by non-Western cultures (Harding, 1998). It is this universalist conception of science that shapes much of the current debate over the nature of science and science education. Over time, this debate has become more polarized and polemical, as universalist supporters of WMS call our attention to what they take to be the dangers posed by constructivist and multicultural critiques (Gross & Levitt, 1994; Matthews, 1994, 1998; Ross, 1996).

While both universalists and constructivists agree that WMS is only one among many ways of describing the natural world, constructivists are far less sanguine concerning the superior of the universalist position. Constructivism itself is not a unitary view and represents a wide range of positions (Geelan, 1997). While some constructivists (e.g., Barad, 1997) support alternative conceptions of realism as part of their argument, other more radical variations of constructivism (e.g., von Glasersfeld, 1989, 1993) describe reality as mainly another social construction which nature plays no important role in shaping. We believe there are good reasons for questioning extreme versions of the constructivist position (Harding, 1998; Rouse, 1996), as we will illustrate later. However, our main task here is to reexamine the problems inherent in the universalist position, because it is such a dominant feature of the current science education curriculum. As we will explain in the next section, it is universalist arguments that are currently employed to attack and reject various constructivist and multicultural approaches to science education.

We begin by summarizing the case for the universalist approach to science education. We then go on to challenge the arguments for epistemic and moral universalism used to defend a universalist conception of science education and argue for an alternative view of science as more “local” than universalist accounts allow. Following this discussion, we try to show how these different epistemological views would play out in terms of decision making about multicultural approaches to the science curriculum. It is our contention that universalists and multiculturalists would employ cross-cultural case studies in significantly different ways.

THE CASE FOR UNIVERSALISM

The case for the universalist conception of WMS (which proponents typically call “science”) rests on several assumptions. First, there is the strong realist claim that reality is

1 Here we are following Harding’s (1998) broad definition of science as applied to a wide range of systems for understanding the natural world in different cultures. Although Harding views WMS as only one among many possible ways to understand the workings of the natural world, she does not take the radical relativist position that one such view is just as good as any other.

2 See Garrison (1997) for a thorough critique of this position.
what it is irrespective of what humans think or know about it. Second, reality is ordered; that is, reality has a structure that is universal and invariant across time and place. Thus, we can say that the structure and forces of the natural world remain the same in different times and contexts. Third, the structure of reality is knowable, at least in part, and WMS has provided the most effective and reliable way to discover knowledge about the natural world. WMS is described as a public and self-correcting process that, in the long run, will overcome the biases of individual scientists or groups of scientists to give us a progressively better understanding of the natural world. Finally, compelling evidence for the three preceding assumptions is provided by the ability of WMS to explain, predict, and control many natural phenomena and the successful application of WMS-derived technology to solve human problems.

Michael Matthews (1994) provides a good explanation of the epistemological universalism at the core of mainstream science. Matthews explicitly rejects what he calls “robust multiculturalism,” or the view of educators like Snively and Corsiglia (1998), that WMS is “just one among a number of equally valid and truthful sciences, each of which has its own logic and its own facilities for truth validation” (Matthews, 1994, p. 181). According to Matthews, robust multiculturalism amounts to the strong relativist position that since “different knowledge systems are equally valid...there is no good cognitive reason to introduce Western science to traditional cultures” (p. 185). In contrast, Matthews contends that WMS is an “intellectual activity whose truth-finding goal is not, in principle, affected by national, class, racial or other differences” (p. 182). Since this form of science provides our best knowledge of the natural world, it is our obligation as educators to expose children of all cultures to such knowledge.

Matthews acknowledges that culture can have a strong influence on how individual scientists and groups of scientists go about their work. But, in the long run, cultural influences do not determine the adequacy of scientific knowledge. In a widely cited passage, Matthews states:

The core universalist idea is that the material world ultimately judges the adequacy of our accounts of it. Scientists propose, but ultimately, after debate, negotiation and all the rest, it is the world that disposes. The character of the natural world is unrelated to human interests, culture, race or sex. Ultimately, the concept is judged by the object, not the other way around. Just as volcanic eruptions are indifferent to the race of those in the vicinity, . . . 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. (1994, p. 182)

Matthews’ views reflect the widespread support for universalism among scientists and science educators. Like Matthews, Gross and Levitt (1994) base their critique of constructivist and multicultural accounts of science on universalist assumptions. They acknowledge that humans do produce cultural constructions of scientific knowledge, but this sort of knowledge is irrelevant, because social knowledge cannot be imposed on reality. In the end, reality requires that “even the boldest imagination” must conform to its authority (p. 234). Thus, science is not mere interpretation. When modern Western scientists make discoveries about the natural world, they are claiming that their representations (e.g., hy-

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1 While we believe there are similar universalist assumptions in the arguments of Matthews, Siegel, and Gross and Levitt, their views are certainly not identical. The version of realism held by Siegel and Matthews is not as dogmatic as that of Gross and Levitt.
potheses and theories) are telling us something about a part of reality as it actually is in itself (p. 262). Ultimately, the force of reality is more powerful than any cultural attempt to interpret it. Steven Weinberg makes a similar sharp distinction between nature and culture when he argues that the laws of nature are immutable, whereas everything cultural is transitory:

Whatever cultural influences went into the discovery of Maxwell’s equations and other laws of nature have been refined away, like slag from ore. Maxwell’s equations are now understood by everyone with a valid comprehension of electricity and magnetism. The cultural background of the scientists who discovered such theories thus becomes irrelevant to the lessons we should draw from such theories (Weinberg, 1996).

Harvey Siegel (1997) also agrees with Matthew’s defense of epistemic universalism and has offered his own critique of social constructionist and multiculturalist attacks on WMS (Siegel 1997). Arguing that critics of epistemic universalism are wrong (e.g., Hodson, 1993; Stanley & Brickhouse, 1994) and that Matthews (1994, 1998) is right, Siegel goes on to defend a weak version of multicultural science education based on moral universalism. In his estimation, there is no intrinsic tension between the epistemological and moral universalism needed to support a multicultural approach to science education.

Siegel (1997) argues that “as educators, we are obliged to embrace multiculturalism, simply because we are morally obliged to treat cultures other than our own, and members of those cultures, justly and with respect” (p. 97). This moral imperative is not limited only to those cultures which recognize it, but is binding on all cultures. “It is because those cultures which fail to treat other cultures and their members properly are mistaken in their treatment—because, that is, there is something (morally) wrong with such treatment—that multiculturalists can compellingly make their case” (p. 97). Absent such a universal moral claim, multiculturalists have no secure basis for imposing their views and fall victim to the limitations of radical relativism; that is, that one point of view is as good as any other, or, at least, that we have no principled way to justify the preference for one belief over another. Consequently, “treating cultures and their members justly and respectfully, [is] a culturally-transcendent or transcultural ideal” that is binding on all cultures, including those “which do not recognize it as a moral truth or imperative” (p. 98).

Siegel argues that respecting the scientific beliefs and ideas of other cultures “does not require that those ideas be treated as correct, or as correct as the scientific ideas of the dominant hegemonic culture” (p. 101). In fact, exposing students from non-Western cultural backgrounds to the superiority of Western scientific methods and knowledge while exposing the epistemological deficiencies of their own culture’s scientific ideas is essential to good science education. Siegel recognizes that we need to act with caution and sensitivity and that Western science educators have not always done so. Nevertheless, to expose students to the best available knowledge, including ideas that clash with their own cultural views, is not only not disrespectful to students from other cultures, but an essential dimension of what it means to educate (p. 104).

Siegel’s argument regarding moral universalism as the basis for multicultural science education is a curious one. He appears to be saying that the proof of the existence of a universal moral principle is derived from demonstrating the impossibility of holding other cultures to any moral principle unless such a principle were, in fact, universal. Certainly, universal consensus regarding a moral principle would make it much easier to apply across cultures, but such consensus would not prove the universal validity of the principle involved. However, Siegel’s argument does not depend on consensus. One culture (e.g., Western) can impose a moral principle on another culture on the basis of the principle in
question being universal. But the only evidence Siegel offers for the universality of the principle (e.g., respect for persons) is that it does appear to be universal from the perspective of Western thought and, absent such universality, the principle could not be imposed on another culture which did not accept it as universal.

This circular line of reasoning begs many questions: Where did the moral principle we seek to impose come from? How do we know it is universal? Even within the framework of Western philosophy, there is no consensus regarding the universality of moral principles. Siegel’s argument seems hopelessly self-serving—exactly the sort of narrow thinking that has troubled multicultural critics of Western science. While we would accept that education involves confronting students with ideas that might conflict with their own cultural heritage, we cannot, for the reasons stated above, support Siegel’s argument for moral universalism as the basis for a multicultural science education. Furthermore, we need to recall that Siegel’s argument also entails a universalist conception of epistemology. But, if epistemological universalism is itself problematic, then Siegel would have difficulty sustaining his argument for multicultural science education even if moral universalism were acceptable.

SCIENCE AS LOCAL AND MULTIPLE

A number of scholars have already offered critiques of universalism, and we make no attempt to recount or summarize this wide range of scholarship (Alcoff, 1996; Harding, 1998; Rouse, 1996). However, we would like to focus on what we take to be some important limitations of the universalist conception of scientific knowledge. Furthermore, we wish to advance an alternative view of science that is far more “local” than is described by a universalist account. In particular, we will argue: 1) Our ability to understand nature is constrained by the limits of human cognitive abilities; 2) The observer is part of the reality that is observed, thus social construction plays a role in the scientific account of physical reality; 3) We cannot determine if reality is either uniform or invariant; reality may best be described as a flux; and 4) We can, however, make a case for the disunity of science (Harding, 1998), since the cognitive content of the sciences is shaped by culturally different forms and social organization of research.

Science and Human Cognition

George Johnson (1995) asks us to consider the possible limits of human cognition as they apply to the process of scientific inquiry and our attempts to understand the natural world. The history of science describes a variety of possible approaches to understanding the nature of reality. Scientists have proceeded along particular paths and not others, assuming that they are moving toward an ever more accurate account of the natural world. However, in this quest, science may “have ventured so far in one direction that it is impossible to go back” (p. 5). Indeed, scientists might find it difficult to even imagine how things might be otherwise.

Johnson’s views echo a related argument made more than a century ago by the philosopher C. S. Peirce, who observed that we must begin our inquiries “with all the prejudices we actually have when we enter the study of philosophy. These prejudices are not to be dispelled by a maxim, for they are things which it does not occur to us can be questioned” (Peirce, 1955, pp. 228–229). It is not possible for a community of inquirers (or an individual for that matter) to call all their assumptions into question at once. To begin with, some of our assumptions are so deeply imbedded in our discourse that either we are not conscious of them or, if we are, it would not occur to us that they could be questioned.
Furthermore, when we do suspect some of our assumptions, there is no way to question them without assuming many others are valid, even though we cannot confirm those assumptions we must hold as valid in the process. Humans could not even think if they did not assume (or act as if) certain things were true. Thus, as humans, our prejudices are not merely a difficulty we must learn to live with but something without which human life, including science, would not be possible (Alcoff, 1996).

Throughout history, humans have exhibited a tendency to compress (or simplify) the information they find in the world. Our attempt to recover order from apparent randomness seems to be one of our most basic human drives. So too, scientists’ “search for neat, predictable, curves, compact ways of analyzing the data” (Johnson, 1995, p. 5). The risk, however, is that we might confound illusion with reality as we come to insist that the orders we invent and the lines we draw are real (p. 13). But, Johnson cautions, “the question remains as to what degree the orders we observe are out in the world and to what degree they imposed by our nervous systems, the inevitable spectacles that refract everything we see” (p. 18). As scientists fall under the influence of various theories and hypotheses, it becomes difficult not to see evidence that confirms our positions.

The cognitive problems involved in trying to understand the natural world are compounded by the technological complexities involved. It is necessary to employ incredibly complex and sensitive devices to detect the traces or effects of the components of reality our experiments predict. Instrumental complexity and sensitivity complicate our ability to control the random disturbances we call noise and to judge which measures are data and which are noise. How can scientists be certain that nature has caused the experimental readings as opposed to the very complex machinery used in the experiment?

Given such complex and sensitive conditions, the human propensity to detect patterns might increasingly result in seeing data where, in fact, there is only noise. In such experimental situations, the connections between our cognitive maps and reality are extremely delicate, and we are in danger of succumbing to the problem of retrospective realism. In other words, “[t]he experimental design that produced the right result is retrospectively taken to be correct; the ones that failed to find the phenomena are judged to be mistaken. The particle exists because it was verified by the experiments; the experiment is deemed to have been designed correctly because it found the particle” (Johnson, 1995, p. 56).

WMS has assumed that the existence of a universal and invariant structure of reality combined with scientific methods can overcome the limits of human cognition, as well as various cultural constraints, as these factors influence the process of scientific inquiry. However, such assumptions can only be postts. Scientific progress is apparent within the constraints of certain contexts and historical periods, not something we can confirm in a universal fashion (Margolis, 1993, 1995). We will return to a more detailed explanation of this position in a subsequent section. In the final analysis, “there is no way to know whether science is converging on a single truth, the way the universe really is, or simply building artificial structures, tools that allow us to predict, to extend, and to explain and control” (Johnson, 1995, p. 6).

Limitations on Our Conceptions of Realism

While humans do require knowledge systems that are reliable and account for real material consequence, such knowledge is possible without resorting to strong realist or universalist claims. WMS can be conceived as an unusually effective (often the most effective) system for gaining knowledge of the natural world in specific contexts and for particular purposes. The effectiveness of WMS has been demonstrated in numerous contexts, and it makes good pragmatic sense to follow such practices, even if we cannot
establish beyond a doubt that it is the existence of universal structures independent of human consciousness that guides our emerging understanding of the natural world. To say this is not to reject realism per se. Even a radical social constructivist must presuppose "a reality independent of all social constructions, because there has to be something for the constructions to be constructed of" (Searle, 1995, pp. 190–191).

However, while we can conceive of good reasons to presuppose (act as if) there is a reality independent of human conceptions, it is also the case that the reliable and effective knowledge of the world provided by WMS is not the same thing as "that" reality. As Searle (1995) points out, the argument for external realism only contends that "there is a way things are" independent of human thought without claiming to describe "how" such reality is in some specific sense. In fact, we can construct a wide variety of systems to represent what we take to be reality, and any of these might come undone through the process of falsification (itself subject to reinterpretation). This line of reasoning does not deny the value of WMS knowledge, but does problematize our conception of brute facts. According to Karen Barad (1997), "either we must accept that scientific statements do not refer to brute facts or that brute facts are not identical with facts that exist independently of us" (p. 6–7).

Barad (1996) proposes a different conception of scientific knowledge she calls "agential realism," a view derived from the work of physicist/philosopher Niles Bohr. Her position is complex and we do not do justice to it here. In brief, Bohr's quantum theory is based on a view of "quantum wholeness or the lack of an inherent distinction between the 'object' and the 'agencies of observation'" (p. 170). This condition exists, because, in quantum theory, measurement interactions cannot be eliminated from the process of describing objects in the world. An example of this phenomenon is the description of light as either a wave or a particle, depending on the measurement process used to describe the object (pp. 177–179).

Particular instances of wholeness are described by Bohr as phenomena; that is, non-dualistic accounts of the world in which objects and agencies of observation constitute a single situation. Within this framework, experiments are understood as an unambiguous process for describing the conditions necessary to reproduce an event and its related phenomena. Objectivity, in this context, is unambiguous communication about a phenomenon, as opposed to the Newtonian conception of the independent observer whose statements correspond to a separate reality. An ontology consistent with Bohr's view holds that "[p]henomena are constitutive of reality. Reality is not composed of things-in-themselves or things-behind-phenomena, but things-in-phenomena" (Barad, 1996, p. 176). Consequently, Barad's conception of agential reality is a way of describing human participation within nature.

Nature is, no doubt, influencing our conception of it, but we only have an indirect way of understanding this process and can never completely remove the observer from the interpretation. Thus, while it is true that we do seek a correspondence with reality in scientific method, "the correspondence in question is between our theories and agential reality not an observer-independent reality" (Barad, 1996, p. 177). In other words, WMS knowledge of the natural world is not merely the result of some particular biases per se, but shaped by quantum theory itself, which holds that the process of observation (e.g., measurement) cannot be dualistic. It is not a case of culture displacing nature, as critics of constructivism (or some radical constructivists) might suggest. "The observer does not..."
have total agency over passive matter—not any representation will do—since not any result one can think of is possible: the world “kicks back” (p. 188). But neither does our understanding of reality exist outside of culture. Our knowledge of the world is not innocent; “it doesn’t ‘just come out that way’ all by itself” (p. 188). Agentual realism presupposes the existence of external realism independent of consciousness and representations, while providing a possible model for understanding the role social construction plays in the scientific account of physical reality.

Thus, the strong realist and universalist claim made by Matthews, Siegel, Gross and Levitt, and others regarding the correspondence between the natural world and our conception of the natural world is not compelling. Furthermore, we reject, as another false dichotomy, the simplistic view that either one is a realist or an antirealist. As Searle argues, we cannot prove the existence of the external world because such a claim always requires external realism as a presupposition (p. 6). But to accept this conclusion does not preclude operating on the basis of a more limited conception of realism.

Science and Nature as a Flux

Universalism depends on the assumption that nature is structured and invariant. A philosophical alternative to this is presented in the recent work of the pragmatist philosopher Joseph Margolis (1993, 1995). For Margolis (1995), the current “master theme” and question for philosophy is this: Does reality have an invariant structure, as universalists assume, or is it a flux? If reality is a flux, as Margolis contends, “then only the contingencies of human thought can determine what to make of reality and our capacity to understand ourselves and the world . . .” (p. 2).

Margolis argues as follows: First, our investigations of the world are mediated by our conceptual frameworks and we cannot determine if our knowledge of reality “directly ‘corresponds’ with a reality that exists independent of our inquiry process.” In this sense, reality is intransparent. There is no unmediated human access to what we call the natural world. Second, the structure of our thought and our understanding of the structure of reality are thoroughly symbiotized. In other words, there is no principled way to determine what part of our conception of reality is an effect of our mental processes and what part is determined by the actual (brute) structure of the world. Third, human thought is histori- cized. All our conceptions of the world (including human thought, the nature of reality, scientific methods, and so on) are artifacts of our particular sociocultural histories. Consequently, all those things we take to be necessities (e.g., the universal structure of reality) only appear to be so within the constraints of our historical conditions. Finally, the structure of human thought is both “performed and self-modifying.” Thus, all of our most compelling forms of knowledge are, in fact, derived from “antecedent enculturating processes” that are beyond our complete understanding. In addition, by participating in this process (as we must) we are constantly reshaping it and altering the conditions of future encultur- ation (Margolis, 1995, pp. 2–3).

Consequently, reality is best understood as a flux rather than uniformly structured and invariant, and we can no longer argue that our cognitive conjectures enable us to progressively approximate the real structure of the natural world. Margolis (1995) uses flux “in the sense . . . that a changing world may manifest stable and discernable structures, even structures that appear not to change over time, without it being the case that apparent ‘invariance’ is a necessary feature of the world (de re) or of our discourse (de dicto)” (p. 8). What we understand as real (apart from our investigation of it) is itself a product of our symbiotized inquiries. In our praxis, all our discourse is intrinsically interpretative (p. 9). As such, all our sciences are human sciences, and “reality—whatever we can make of
it—is an artifact of the consensual practices of viable human communities, but not for that reason not ‘brute,’ not ‘external’ (p. 17).

Harding (1998) also argues that nature is not uniformly organized or static. Societies and their sciences do not have access to all possible observations of nature. Furthermore, diverse interests have led to distinctive interventions into nature, and these interventions change nature (e.g., the human impact on weather). The constant human interaction with the natural environment, at a minimum, problematizes the unity of science position (p. 67). But even if nature were unified, we would have access to only those observations in our geographic and historical era and still not have access to a single valid representation of all of nature. A related problem is the possible disunity of nature itself, as well as the disunity of WMS as a practice. Dupre (1993) argues that nature is heterogeneously organized. In other words, “the disunity of science is not merely an unfortunate consequence of our limited computational or other cognitive capacities, but rather reflects accurately the underlying ontological complexity of the world, the disorder of things” (p. 6).

The Social Organization of Research and the Disunity of Science

Whatever the actual ontological status of the natural world, Harding (1998) describes the history of the multiple, but unsuccessful, attempts by philosophers to support a unity-of-science thesis. All such attempts to find unity across the sciences have failed. Thus, WMS is best conceived as multiple sciences, since “there is no set of features peculiar to all the sciences, and possessed only by the sciences. There is no necessary and sufficient condition for being a science” (Hacking, 1996, p. 68). In order for scientists to communicate with one another across diverse cultures, they have had to invent unifiers. Mathematics has been recognized to serve such a function. However, in practice, there is no single mathematics either, as mathematicians employ a wide range of different principles and techniques that are not reducible to a single system (p. 176). Similarly, other “temporary, local universalizing strategies are devised in the face of the de facto unavailability of reliable universality claims” (p. 171).

One example of this process is the long project that developed the hydrogen bomb. In the 1940s and 1950s, H-bomb designers, statisticians, logicians, and aerodynamical engineers were brought together to create computer simulations. In the course of their discussions, physicists found they thought of “randomness” in very different ways than statisticians. Thus, they had to devise a working definition of “random enough” that borrowed from several cultures, but belonged exclusively to none (p. 171). Consequently, nature is not best described as universal. Science is not best described as universal. The observation of the disunity of the sciences is consistent with Margolis’s argument that describes nature as a flux.

Perhaps the best illustration of the disunity of WMS can be found in the work on the cultural studies of science and its insistence on the “local, material, and discursive character of scientific practices” (Rouse, 1996, p. 247). WMS is conventionally described as a universal mode of reasoning that can transcend the effects of cultural mediation and material practices when it is employed to understand the natural world. In contrast, cultural studies of science emphasize the importance of specific complexes of instruments and specialized materials, as well as the skills and techniques needed to use them, in shaping the sense and significance of knowledge (p. 247).

One of the many examples of this is the work of anthropologist Sharon Traweek (1988) in studying high-energy physics. Traweek describes the importance of the detector in accelerator research groups. Although these groups record pulses from the same beam,
what knowledge is produced from these data is dependent on the kind of detector they use. Whereas the U.S. detectors are typically constructed by research physicists and frequently modified and replaced, in Japan, although the physicists may specify the general design of the detector, they are produced in industrial firms. They are typically difficult to alter and sufficiently expensive that they must be used for a much longer period of time than those in the United States. The reason for the difference in approach is that in Japan funding is closely tied to corporations. Traweek then documents how these differences strongly affect the kinds of questions that can be asked, as well as the characteristics of good results. The universalist account of science de-emphasizes the significance of this kind of counter-evidence in asserting the influence of culture is corrected by the brute force of evidence from the natural world. There are a large number of other examples (see Rouse, 1996) that support the claim that culture influences (but certainly does not determine) the truth claims of science.

IMPLICATIONS FOR SCIENCE EDUCATION

One might wonder why these arguments about multiculturalism are important ones for science educators whose primary concern is how best to educate our youth in contemporary classroom settings. We believe that these arguments have important classroom implications because universalists and multiculturalists would likely approach instruction in significantly different ways.

As noted earlier, Siegel (1997) argues that advocates of multiculturalism must use culturally-transcendent ideals in making their case. “Consequently, the advocate of multiculturalism must see the requirements of avoiding cultural domination and hegemony, and of treating cultures and their members justly and respectfully, as itself a culturally-transcendent or transcultural ideal” (p. 2). At times, Siegel’s discussion is very general and abstract, so stripped of contextual detail that it is difficult to ascertain what Siegel might mean when he uses words like “justice” and “respect.” Furthermore, Siegel claims to know what these universal ideals are. We are far more skeptical of not only Siegel’s claim to know what is universally right or wrong, but of the very possibility of attaining such knowledge. A more plausible view is that moral ideals are worked out by practitioners in historically specific and contingent contexts. Fish (1994) argues that all norms (including ethical norms) are:

specific, contingent, historically produced, and potentially revisable . . . since those who are embedded in local practices—of literary criticism, law, education or anything else—are “naturally” heirs of the norms and standards built into those practices, they can never be without (in two senses) norms and standards and are thus always acting in value-laden and judgmental ways simply by being competent actors in their workplaces. The post-structuralist characterization of the normative as a local rather than a transcendental realm, far from rendering ethical judgement impossible, renders it inevitable and inescapable. (p. 39)

Consequently, Siegel’s claims ought to be judged based on the framework of his epistemology, as well as what actions he would take in a given classroom situation. Fortunately, Siegel (1997) reveals some of his own reasoning when he illustrates how he would decide what kind of science education to provide non-Western students. He concludes that “there is nothing morally suspect about suggesting to anyone, including members of non-Western cultures, that their views about the natural world are epistemically or scientifically deficient” (p. 9) so long as the way in which this is communicated to the student is respectful.
The question for us is whether his actions represent the enactment of a transcultural ideal or the imposition of his own Western ideals (which he confuses as transcultural) onto someone who may or may not share his ideals. His decision is based rather simply on the belief that Western scientific ideas are better than all contenders and that exposure of students to the best ideas is what education is all about. A rather striking omission here is any mention of a dialogue with these non-Western students or other members of their culture. His decision has nothing to do with their values. His decision is based on his own values. Since Siegel cannot know what the “best” ideas are in this instance, he has reasoned beyond his own epistemic system. Certainly, Siegel might propose some basis for presenting WMS to students from non-Western cultures in certain contexts. However, he cannot make the case based on the assertion that WMS is the “best” understanding of the natural world.

In effect, Siegel is willing to make a decision about what is respectful by appealing to a Western cultural principle (which he confuses with a general moral principle) while simultaneously ignoring much of the particular instructional context. For us, making a decision about what kind of science education to provide students from non-Western cultures would be far more difficult. In addition to epistemological and moral factors, political factors would also have to be taken into account. It would help to talk to the students and to other members of their culture to learn what concerns they may or may not have about WMS. For example, we might want to know the extent to which non-Western students are concerned that learning about WMS is a threat to the survival of their culture and to what extent they desire access to WMS. Discussions about what might be the advantages and disadvantages of a monocultural vs. multicultural approach to science education might also be helpful. The students’ wishes, their positioning within both the school and society, are important factors to consider. Multiple and perhaps competing values of respect, empowerment, critical thinking, and survival would have to be taken into account. The instructional decisions would require practical reasoning about these multiple and conflicting values (Brickhouse, Stanley, & Whitson, 1993). It is impossible to say in advance what the result of these negotiations and discussions would be.

Multicultural education, of course, should not be concerned about the education of non-Western students alone (Stanley & Brickhouse, 1994). We argued that WMS ought to be taught as a part of a culture (rather than as transcultural) and that teaching students cross-cultural case studies would help them understand about other cultural views of science as well as some of the basic tenets and assumptions of WMS that may otherwise be invisible. An example of a cross-cultural study of Western science and Chinese science was recently presented at the Third International History and Philosophy of Science in Science Teaching Conference (Brickhouse, 1997). TEK, as outlined by Snively and Corsiglia (1998), could also provide resources for such a cross-cultural comparison. The potential value of such instruction has been endorsed by multiculturalists (Hodson, 1993; Snively & Corsiglia, 1998; Stanley & Brickhouse, 1994) and universalists alike (Matthews 1994; Siegel, 1997). As Siegel (1997) states, “No friend of universalism in science education need fear such questions, rather, any such friend should welcome them, since pursuing them will provide the opportunity for students to learn about those features of science of which universalists are so fond” (p. 13).

However, while there may be considerable agreement that the study of cross-cultural cases would be valuable, we believe that the way they would be used by universalists and multiculturalists would necessarily be quite different. Both Matthews and Siegel state the criteria they would use to compare WMS and examples of sciences from other cultures. However, their criteria are both vague and derived from what they view as the most

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important characteristics of WMS: “explanation, grasp of non-observable causes, testability, successful prediction of the unknown, and the ability ‘to grasp the truth of the matter’” (Matthews, 1994, p. 193).

Furthermore, Matthews and Siegel both claim to know in advance what the result of such a comparison would be; that is, “... no ethnic science is going to adequately explain how radios work, why the moon stays in orbit, why hundreds of thousands of Africans are dying of AIDS, and so on” (Matthews, 1994, p. 193). Not only are the criteria they use in assessing the sciences derived from their culture-bound views of the strengths of WMS, but the problems they believe all sciences should be interested in solving are really local problems that would be of most concern to Westerners. If the question were to explain the anesthetic effect of acupuncture or how to live with limited resources, WMS might not fare as well. Given the constraints of their approach, a cross-cultural case study taught by Siegel or Matthews would clearly result in an a priori victory for WMS.

The cross-cultural case approach prescribed by Snively and Corsiglia (1998) delineating a five step process for teaching TEK and WMS is certainly not objectionable to us. They provide examples that lead to rather clear conclusions: 1) we should credit indigenous healers with the discovery of Aspirin® 2) officials should have listened to the Nisga’a fisherman’s claim that a new molybdenum mine was threatening crabs, 3) combining TEK and WMS can be very powerful, and 4) Westerners can be chauvinistic in their attitudes toward people different from themselves. While we do not disagree with these conclusions, we worry that focusing on these issues alone would be a missed opportunity for teaching about other aspects of the nature of science. Snively and Corsiglia’s examples (with the exception perhaps of #3) emphasize the politics of science. Science is, of course, political, and this aspect of science should be taught. Snively and Corsiglia provide very powerful examples of teaching students about the politics of exclusion in science and science education. Science is, however, more than just politics.

While we agree with the political aspects of the position posed by Snively and Corsiglia, we disagree with some of their epistemological arguments. For example, they repeatedly use the methods of science to support a unity-of-science thesis. In reference to the Nisga’a fish wheel, students are asked “Did they observe, infer, question, and build models?” (p. 40). The conclusion students are to draw is that they participate in the methods of science and are, therefore, doing science much like their Western counterparts. The problem is that the methods of observation (inferring, observing, and so on), are not unique to science and cannot demarcate science from other endeavors. To repeat our earlier arguments, the sciences are disunified and multiple. There is no unique set of characteristics that define science. Hence, whether or not the Nisga’a are doing science cannot be answered by this question.

Secondly, Snively and Corsiglia (1998) state, “Discussion should stress similarities as well as differences, and areas where IK [indigenous knowledge] helps fill the gap where knowledge in WMS is lacking, and vice versa” (p. 40). One concern we have about this statement is that it seems to suggest, as Harding (1998) describes, that there is just one big elephant and one true story about the elephant. From this perspective, IK, TEK, and WMS are simply looking at different parts of the same elephant. Perhaps if we put together IK, TEK, and WMS we might get the one true story of the elephant. For reasons stated earlier, we do not believe the one true story is possible.

The kind of borrowing across cultures described here has quite a long history. WMS has borrowed ideas and technologies from all over the world. Similarly, indigenous people have often selected particular aspects of WMS that they find useful. However, this borrowing to “fill the gap” is done in a very narrow and limited way. For example, acupuncture
can increasingly be found in U.S. hospitals for alleviating pain. However, while acupuncture is being integrated into mainstream medical practice, the accompanying explanatory ideas about chi are not. Perhaps the integration of specific technologies or ideas is possible across cultures, but the integration of large, explanatory frameworks and philosophies is not. In fairness to Sniveley and Corsiglia, they do describe the holistic elements of IK and TEK that do not correspond to (or are ignored by) WMS. We believe that this insight is important and requires further study.

Rather than merely showing students that IK and TEK are different from WMS (and possibly suggesting they were inferior), our approach would be to show students how these different views of science are firmly rooted in certain cultural assumptions that influence how they go about formulating and solving problems of significance. Furthermore, rather than teach a particular view of science or pretend as though the nature of what we were teaching was uncontroversial, we would then teach students about the controversy over what is to be included in the science curriculum and how such decisions might be made. Our approach would include an examination of the debates within WMS.

We agree with Matthews (1998) that, in teaching about the nature of science, it is irresponsible to teach a particular viewpoint of science as though it were uncontroversial when it is not. It is important (and educationally useful) for students to at least understand the different viewpoints regarding science and our understanding of the natural world. It is not the responsibility of the teacher to compel belief in her position. Of course, Matthews and Siegel are primarily concerned about constructivists teaching their particular view of science because they disagree with such positions. We are more concerned that universalist conceptions of science are taught as if they were neither controversial nor problematic. Typically, the school science curriculum contains only ideas on which there is very widespread consensus; that is, they are uncontroversial in the field. However, although almost everyone agrees that we ought to teach students about the nature of science, there is considerable disagreement on what version of the nature of science ought to be taught. It is interesting that, while educators often argue about what should be taught among themselves, they rarely include students in such controversies. This is quite unfortunate, since the debate itself is potentially of enormous educational value.

As we have argued, the study of such debates would provide a way of teaching students about the relative merits of different sciences, as well as giving them a better understanding of WMS. For example, what questions is WMS good at answering? What kinds of problems do TEK solve? In addition to the ability of these sciences to solve particular problems, is one of them simply more likely to be true than others? If so, how would you know? What historical conditions may explain why WMS arose primarily out of Western European culture rather than elsewhere in the world? What are the similarities between TEK and WMS? Would it have been possible for TEK to have become a part of our culture at some point in history? If it had, how different might our culture now be? How do other belief systems (e.g., religion) interact with TEK, Chinese science, and WMS?

Multicultural education, at its best, should introduce students to new ways of thinking about the natural world. This kind of education not only helps them to understand other ways of thinking, but also helps them to understand some of the fundamental tenets of Western ways of thinking. This shift in thinking that was initiated, at least in part, by contact between the East and the West and other cultures is precisely the kind of shifts in thinking that the best of multicultural education can provide our students.

5 This has been recommended by Cain and Graff (1994) as a way of dealing with the dispute over the canon of literature classes and by Brickhouse and Letts (1998) in teaching about evolution.
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