Articles

Engaging Science Education Within Diverse Cultures

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ABSTRACT

At the heart of discussions about an appropriate school science in a diverse world are questions about the status of modern science versus other schemes for understanding the natural world. Does modern science occupy a privileged epistemological position with respect to alternative beliefs? There has been a movement from an emphasis on replacing students' ideas based on traditional cultures to one of respecting those ideas and adding to them an understanding of modern science ideas and an exploration of when each might be useful. Respecting both sets of explanations need not deny discussions about credibility in particular contexts. School science, however, is always located within wider educational and political structures. Broad elements of the community must be engaged in dialogue concerning what knowledge about the natural world is important, to whom, and for what purposes.

INTRODUCTION

I recently visited a small Dayak village near the headwaters of the Mahakam River in East Kalimantan, Indonesia. The river was the main highway in and out of the village, although we had arrived on a small, nine-passenger plane that landed on a grass strip in a jungle clearing just up the river from the village. There were no roads to the village, no telephone lines, no pylons bringing in electricity. There had been no way of communicating with anyone in the village prior to our arrival. In many ways the people lived a traditional hunting and gathering Dayak lifestyle. Yet out of the grass-roofed buildings rose poles on which were large satellite dishes capable of receiving television signals. Each evening, as the sun went down, local electricity generators were turned on and many of the villagers sat

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watching the evening news and programs originating in far-off cities, exploring the lives of other Indonesians and people from other countries. The separation between traditional and modern cultures is eroding as each finds a place in today's cultural and economic practices. Traditional knowledge is valued for survival in a village that is still largely dependent on the surrounding jungle for food and building materials. Modern science and technology is valued for the generators it provides, outboard motors for river taxis, and new forms of entertainment. Modern technologies are a part of every life, wherever one may live today.

Although I was not there to teach, as a science educator I was intrigued by the question of how the people understood the workings of these modern machines and what sense they made of the television images of traffic jams, skyscrapers, and modern homes as well as advertisements for cosmetics, clothes, and furniture that were not a part of their own environment. What would an appropriate science education look like? What should be taught, how should it be taught, and who should decide? Could ideas about cells, microbes, and DNA have any basis for competing with the wisdom of traditional knowledge and the sense of shared identity and community that was embodied in traditional practices? Clearly, the arrival of some new technologies was welcomed and having an effect on community life: watching one of the numerous televisions had become a major social practice in the evening. The community was not static. Modern medicine and formal education were a part of it, as were other forms of healing and informal education. Despite geographical isolation, there was an exchange of goods and ideas up and down the river. Some young people had left for jobs in the cities at the mouth of the river and returned up river periodically for family visits and celebrations. Some people from down river arrived to collect nests found in caves that are valuable for making bird's nest soup. The ideas of modern science might be "foreign" to members of the village, but they were not necessarily incomprehensible. The comments of Ogunniyi in an African context could apply to the Dyak.

> If the African can absorb technological products without mental conflicts, it is certainly not impossible to design ways and means that will help him absorb scientific interests, attitudes, thoughts, and habits without destroying his identity or religious sentiments. (Ogunniyi, 1988, p. 8)

The challenge of designing the ways and means of understanding scientific ideas and practices without destroying identity and religious sentiments is great, maybe even impossible, and the resolutions will vary in different contexts in different communities. The growing literature on "multicultural" science education reflects a number of settings such as recent immigrants to the United States (see Chang & Rosiek, this issue), indigenous peoples in North America (Aikenhead, 1997; Snively & Corsiglia, 2001) or New Zealand (McKinley, 1996), and non-Western students in third-world countries of Africa (Jegede, 1994) or in first-world countries such as Japan (Ogawa, 1998). In coming to terms with the interaction of science with issues of identity and religious sentiments in each of these cases, there are decisions about what constitutes appropriate science given the history and culture of the community and judgements about how that history and culture affect teaching and learning. In different communities there will be variations in the extent of opposition between religious and scientific beliefs, and variations in the vulnerability of peoples' sense of identity related to their position relative to the dominant society or, within Africa and Japan, with respect to dominant ways of thinking within the wider world. As Chang and Rosiek's sensitive and complex discussion of a possible response to a Hmong student's challenge to a Hmong science teacher about whether he actually believed in the biology of disease that he was teaching illustrates, the political and cultural contexts of science teaching must be addressed. For many scientists and science teachers for whom science is the model of rationality and truth, this is an extremely difficult perspective to understand, let alone assume. The vehemence of the so-called science wars (Gross & Levitt, 1994; Ross, 1996) is just one indication of the overheated rhetoric that is sometimes generated. Chang and Rosiek, working within the context of Hmong immigrants to the United States, articulate a possible resolution between the conceptions of disease within science and traditional Hmong beliefs about disease and its treatment. It is a resolution that maintains the integrity of modern science while acknowledging that the health of a community and of the individuals within it requires respect for its cultural traditions. But this position can itself be located within a healthy debate about the nature of school science in a diverse society. Decisions about how to proceed need to engage a broad community and explore the various options and their implications for the students, the community, and the way we think about knowledge.

First a note about terminology. How should we label the dominant science that is taught in schools? Many writers use the term *Western modern science* or *Western science* (e.g., Cobern & Loving, 2001; Ogawa, 1995; Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001) to refer to the version of science found in standard science textbooks. The adjective "Western" is used to highlight two things. First, the use of the word "Western" in front of science highlights the view that modern science had its origins in ancient Greek and European culture (Cobern & Loving, 2001). Needham (1969), however, argues that although modern science was born in Europe, people of Asian cultures helped lay the foundations of mathematics and science and set the stage for the decisive breakthroughs that came about in the favourable social and economic milieu of the European Renaissance. People of Asian cultures continue to make important contributions to modern science. This is not to say that the contexts of different countries do not affect the kind of contributions they make. Traweek (1988), for example, in her study of Japanese and American high-energy physicists points out that Japanese scientists may, as a result of their different social and economic circumstances, use different kinds of equipment, ask different questions, and use different criteria for what counts as a good result. Nevertheless, the contributions of the Japanese physicists become part of modern physics. Second, and more contentiously, the use of the word "Western" signifies the author's contention that there are other, alternative sciences besides "Western" science. These would include the traditional ecological knowledge of indigenous peoples that has increasingly been recognized for its contributions to modern science, especially in the areas of medicine, ecology, and resource management (Snively & Corsiglia, 2001). Ogawa argues that not only are there multicultures, but also multisciences. Every culture has its own indigenous science and it is possible to study comparative science just as one might study comparative art or religion. Modern science, however, he argues is not an indigenous science but a "theoretically materialistic science," which is "a kind of game open to anybody who will obey its rules" (Ogawa, 1995, p. 589).

My preference is to use the term "modern science" to refer to standard textbook science. Modern science is embedded in an international community of practice that broadly shares journals, conferences, and assumptions about what counts as modern science. The term "modern science" accepts that people from many non-Western cultures have made significant contributions to our modern understanding of the natural world but is also broad enough to encompass the claim that there is no unified modern science (Hacking, 1996).

MODERN SCIENCE, TRADITIONAL CULTURE

At the heart of discussions about an appropriate school science for aboriginal students in industrialized countries, or for students in countries of Africa or Asia with non-Western traditional worldviews, or for third-world immigrant students in first-world countries are questions about the status of modern science versus other schemes for understanding the natural world. Does modern science occupy a privileged position with respect to other systems? Traditionally, student conceptions of nature based on non-Western worldviews have been viewed as superstitious beliefs that were impediments to the health and economic development of a modern society (Maddock, 1981). The strategy of science educators was to work toward the replacement of these traditional ideas or beliefs with modern scientific facts. This approach has been labelled "assimilationist" (Hodson, 1993a) or "imperialist" (Matthews, 1994, ch. 9) because it seeks the perpetuation, transmission, and promotion of the cultural beliefs and norms of the dominant community. Western science curriculum projects were often transported intact to developing countries (Maddock, 1981). The inadequacy of this approach in non-Western countries soon became evident. The difficulties that arose with aboriginal and non-Western immigrants in Western, industrialized countries took longer to be acknowledged.

In a variety of ways, school science can be made more sensitive to the context of minority students without challenging the epistemological privilege of modern science. As Pomeroy (1994) suggests, support systems can be created to encourage increased participation of underrepresented groups in challenging science courses and careers. Examples of support systems might include increased numbers of minority teachers as role models and the use of community members as mentors. The development of an adequate supply of role models and mentors may require special counselling services, scholarships, and enrichment programs to encourage minority students into science-based programs and to support them while they are there.

It is also possible to modify the curriculum to make it more sensitive to local, non-Western environments without challenging the fundamental ideas of science it is trying to portray. This can be done through the use of local flora and fauna and geologic features in the investigation of biological and geological sciences. Additionally, it can be accomplished through exploring the interrelationship of science, technology, and society within the context of the students' immediate lives and in the context of more global issues about which they may be reading and hearing (Jegede, 1994).

Being sensitive to cultural diversity in science can also mean incorporating science into the larger tasks of learning a new language, particularly for new immigrants or for indigenous people studying in a language that is not the language spoken at home. Science for language minority students can be taught in ways that help not just the acquisition of majority language skills but, more importantly, provide opportunities for learning and practicing the particular language structures of science (Lemke, 1990). Frequent opportunities for students to make sense of their natural environment and clarifying particular science concepts through talk becomes important.

It is important to create a picture of modern science in which minority and non-Western students can imagine themselves participating because other people like them have been, and are, a part of it. This can be done by providing examples of people like them who have made significant contributions to modern science. This year's Nobel prize in physics, for example was for work related to Bose-Einstein condensation. The first prediction of this type of condensation was by Einstein who based it on Bose's work on the statistics of photons. Satyendra Bose was born and educated in Calcutta and became professor of physics in Dacca and, later, Calcutta. Needham (1969) points out that three of the most important technologies for the West, the movable-type printing press, gunpowder, and the magnetic compass were each in use in China several centuries before they were in Europe. Broader cultural contributions to modern science can also be illustrated through providing examples of how traditional knowledge and practices either predated their rediscovery by modern science or have gained acceptance by being reinterpreted through modern scientific theories. Reiss (1993) provides an extensive collection of examples of traditional knowledge similar to, but outside the story of, modern science from successful inoculation against smallpox in 10th-century China to the accurate measurement of the period of the Sirius B star by the Dogon of Mali even though the star is invisible to the naked eye. For students in Hong Kong, Tao (1998) illustrates how the use of early Chinese ideas about science such as the "magic mirror" can be cheaply incorporated into practical work in physics classes and explained through modern ideas about the properties of materials. Within modern medicine, the gradual acceptance of acupuncture and its reinterpretation within the principles of neuroscience is another example. Snively and Corsiglia (2001) provide examples from First Nations traditional ecological knowledge, particularly around the management of resources, that can now be seen to be a part of modern ecology.

The worldviews of students' traditional cultures, however, may be in conflict with that of modern science. This can happen at different levels. Cultural mores or taboos may interfere with students performing particular science activities such as dissecting animals (Hodson, 1993a). Jegede (1994), in investigations into the teaching and learning of modern science in Nigeria, identified several sociocultural influences to which science teachers needed to pay particular attention. For example, in some cultures there is a belief that older people, given their greater experiences, should only rarely be challenged or questioned. In classrooms, this deference is extended to the teacher. This predisposition toward deference contrasts with a view of modern science that the soundness of ideas is based on consistency with observable evidence not the age of the speaker. There are also cultural differences in patterns of social interaction. Although there will always be variation within a culture, in some there is a predisposition of individuals to work cooperatively toward common goals and in others there is a greater predisposition toward individualistic, competitive ways of structuring goals. Similarly, in some cultures, success is seen as tied primarily to the characteristics and efforts of the individual; in others, the achievement of an individual is seen more as a reflection on his or her home, friends, and community. School science tends to emphasize the competitive achievements of individuals. Jegede argues that the best way of attending to these sociocultural factors that may make it difficult for students to feel comfortable in modern science classrooms is through science-technology-society curriculum topics that use familiar cultural ideas and materials and links them to various modern science principles.

Particularly challenging to modern science is that one characteristic of traditional worldviews can be lack of a clear distinction between the roles natural and supernatural forces play in daily events. In the modern science worldview, natural and supernatural causes are clearly distinguished. (As Galileo aptly commented, "Science tells you how the heavens go; religion tells you how to go to heaven" (Dava, 1999).) Explanatory systems for disease or acupuncture based on the Chinese concept of Ch'i (Kinsley, 1995) are incompatible with modern science explanations of germs and neurology. It is possible to acknowledge the alternate belief systems of students without necessarily giving such belief systems the status of science. Students can be encouraged to understand how acupuncture worked from the point of view of traditional Chinese ideas of the body and energy flows as well as from the point of view of modern medicine. Such exploration can illustrate how each version is embedded within a coherent system.

A greater sensitivity to cultural difference in the classroom thus does not necessarily lead to a challenge to universalistic conceptions of science. Siegel (1997), while acknowledging the moral requirement to treat other cultures with respect, distinguishes between treating their ideas about nature with respect and treating them *as* correct or at least *as* correct as the scientific ideas of the dominant, hegemonic culture. Ideas from alternative views about nature could be discussed, but those ideas should be compared with modern science in terms of their adequacy and criteria for validity. Modern science, it is assumed, will be seen to be superior in any such comparison. As Stanley and Brickhouse (2001) point out, however, such an assumption assumes that students from non-Western cultures have similar values as Western scientists, identify similar problems as important, and agree on which solutions are the "best" in particular contexts. These assumptions, they argue, are problematic and, in the absence of dialogue about them with the students and other members of their culture, undercut claims of respectfulness.

How then are we to treat alternative conceptions of nature such as the Chinese system of Ch'i? Is it a religious belief or a superstition? Is it an alternative science or an ethnoscience? If we use the terms alternative science or ethnoscience are we implying that modern science is just another ethnoscience rooted in the particular contexts of the modern world? If so, are there grounds for claiming that one form of ethnoscience has a greater legitimacy than another?

THE RELATIVE STATUS OF MULTISCIENCES

These questions open a Pandora's box of issues for science educators and teachers. The idea that modern science is just another ethnoscience questions its universality and its automatic supremacy compared to local knowledges of the natural world. It opens up school science to an exploration of the beliefs, methods, criteria for validity, and systems of rationality upon which other cultures' knowledge of the natural world is built.

Such challenges to the automatic authority of modern science can draw upon recent work in the social studies of science that challenges the idea of the existence of a single, universal science and that illuminates the ways cultural values, purposes, and expectations shape the construction of scientific knowledge (Bingle & Gaskell, 1994; Harding, 1998; Latour, 1987, 1999; Mulkay, 1979; Rouse, 1996; Stanley & Brickhouse, 1994).

Thus one of the questions at the centre of debates about what constitutes an appropriate school science for minority or non-Western students is a fundamental question about the nature of modern science. Is modern science the only real science, with other ideas about nature relegated to religion, superstition or, at most, bad science? If modern scientific knowledge is culture laden, just another ethnoscience, should local indigenous knowledge of nature have the same status as modern science? Are they equally credible? The discussion about this is frequently framed in terms of universalist versus relativist positions (Gross & Levitt, 1994; Snively & Corsiglia, 2001). From the standard, universalistic perspective, nature, not culture, is the final arbiter of knowledge (Gross & Levitt, 1994; Matthews, 1994). Universalists believe that ethnosciences are not true sciences because they are not based on reliable, published, peer-reviewed evidence. People may believe ethnoscience but it is not knowledge. Labelling the alternative position "relativist" suggests that it is not possible to assess the credibility of one version against another and that what is knowledge is dependent on relative social power. The idea that scientific knowledge is not solely determined by nature, however, does not have to entail that it is solely determined by culture. One way around this dilemma is to use the language of actor-networks (Callon, 1986; Latour, 1987, 1999). The "actors" in an actor-network are both human and nonhuman. For a statement to be accepted as true, it must tie together an extensive network of interested humans and nonhumans into stable relationships. Dials on instruments must behave in a predictable fashion but humans must also agree on the meaning of the dials. Social, cultural effects are influential but so are natural, nonhuman ones. Nature does not determine truth, but neither does social power. The process is symmetrical in that through the settlement of a controversy about how to interpret a phenomenon, both nature and society are constructed. Nature and society are the consequence not the cause of the settlement of a controversy. As we decide truths about how nature works, we also decide what we are interested in as a society and what forms of authority we believe.

From within an actor-network perspective, the important question is not one of universal versus relative knowledge but of credibility based on the size and strength of networks. No network is universal but some are much longer and stronger than others. For example, the difference between the weather forecast from the weather office and the forecast of an elder who has lived in a particular location all his or her life is not that one is more or less often correct on a particular day for that particular location. The difference is the number of people and bits of data from around the globe associated with thousands of weather balloons, boats, weather stations, and other instruments that have been accepted as reliable and brought together into readable forms compared with a smaller number of human and nonhuman associations in the local environment. It is not that the meteorologists are scientific and the local elders are not, or that one is rational and the other not: each employs a range of data from extensive experience. The difference is the length and strength of the networks and the number of actors within them that each is able to draw on in making their statements. But this process is recursive since the strength of the network is based on the credibility of the various actors that make it up. In some contexts and communities the elements of the meteorological network may have little credibility and its statements may be too general for the particular microclimate being considered. It becomes not a question of "logic" but of "sociologic" (Latour, 1987, p. 202).

ADDITION OR REPLACEMENT

If credibility is based on the length and strength of networks, then it is possible to move away from the idea that some knowledge is right and others wrong while arguing that some knowledge is more credible than others in particular contexts. Credibility will depend on the community and context within which people are operating, the human and nonhuman actors that must be taken into account. This suggests that the idea of replacing students' traditional knowledge with modern science is too simple. As Aikenhead (1996) suggests, a more reasonable strategy would be to encourage a conceptual proliferation sensitive to specific social and natural contexts. In ordinary conversation, for example, physicists and astronomers will talk about the sun rising and setting as if the earth were stationary and the sun revolved about it. When challenged, they shift their model and are able to describe the phenomena of the changing place of the sun during the day and night using the more awkward language of the stationary sun and revolving earth. They can translate back and forth but find the "minority culture," static earth model easier to use in everyday situations. They are aware of the strengths and weaknesses of each type of explanation for particular social settings and communities of discourse. Students are also able to move easily back and forth between a life world system and the modern science system (Solomon, 1983). This pluralistic perspective has several advantages. It provides a learning environment of respect for the culture of the students. Their culture's knowledge is coherent and rational and is appropriate in particular contexts. The cultural identity and self-esteem of the students is enhanced. Teaching from a pluralistic science perspective also allows questions about science to be raised more easily. Being able to contrast how two systems explain a phenomenon illustrates the assumptions, strengths, and limitations of each system. This type of learning "about science" is an important component of scientific literacy (Hodson, 1993b).

HELPING STUDENTS CROSS BORDERS

If students are moving back and forth between different knowledge systems or cultures, they can be said to be crossing borders between different ways of viewing and acting in the world. The idea of science education as border crossing, especially for minority students, has been developed by Aikenhead (1996, 1997) based on Giroux (1992). From this perspective, the teacher can be seen as a tour guide for students crossing borders between their own local, minority cultures and the culture of the majority, modern science. Students are encouraged to act as an anthropologist, contrasting the ideas about nature from their own cultures with those from the modern culture and learning to translate from one culture to another and learning when each explanation is most appropriate.

Aikenhead (1997), in the context of describing an appropriate science education for Canadian First Nations' students, talks about the importance of making border crossings explicit for students and working to make the crossings smooth. It is possible to visit and learn about another cultural realm such as science without necessarily believing in it. You may just use it for pragmatic ends such as doing well at school. Aikenhead proposes a cross-cultural science-technology-society (STS) curriculum to help in this process. Such a curriculum would emphasize:

> cultural border crossing for the purpose of enhancing students' capabilities and motivations to eclectically draw upon Aboriginal cultures and upon the subculture of science and technology, for the purpose of taking practical action towards economic development, environmental responsibility, and cultural survival. (Aikenhead, 1997, p. 229)

The goal of this process is to develop students who have undergone a process in which a student borrows or adapts some content from modern science and technology because the content appears useful to him or her. The new knowledge may replace some former indigenous views or it may exist alongside them. Everyday thinking is an integrated combination of commonsense thinking and some science/technology thinking.

Border crossing is a metaphor for the experience of many third-world and immigrant students in a modern science class. As with any metaphor, it highlights some aspects of the phenomenon and masks others (Lakoff & Johnson, 1980). In the context of science curriculum for non-Western students, border crossing highlights a sharp boundary or border between the everyday culture of the students and the culture of modern science.

But, as pointed out at the beginning of this article, these students are not living in a traditional world untouched by the ideas and products of modern science. The boundaries between the students' worlds and modern science are already very porous. From television to rockets to modern medicines, students cannot escape taking on, and being a part of, a world shaped by modern science and technology and its cultural effects.

If we incorporate aspects of modern science that are already part of the everyday life of third-world and immigrant children, then science need not be the "foreign culture" that it is hypothesized to be in much of the multicultural science education literature. In other ways, Western science education may have links to traditional cultures that are not at first apparent. Ogawa (1998), for example, analysed modern Japanese science education and found that although there were surface similarities with Western science education, some key concepts such as *Shizen*, a concept of nature, and *Rika*, denoting Japanized science education, drew upon traditional Japanese worldviews for their full interpretation. Thus the expression of modern science education in Japan was different than in North America because it drew upon different historical understandings. The bridge between traditional and modern science education in non-Western societies may be shorter than Western scholars imagine.

Teaching to facilitate border crossings does not mean that children will not continue to have problems understanding concepts of modern science. Most children have such problems—even those who grow up in European and North American societies that are embedded in modern scientific and technological worldviews. For example, Aikenhead (1996) describes the case of Melanie, a reasonably conscientious Grade 10 student in an STS science course who, even after five weeks of student-oriented group inquiry contextualized in the historical development of heat, still had not constructed a modern conception of heat and temperature. For Melanie, STS content made her science class more interesting and provided alternative content on which she was evaluated to her advantage, but it did not make traditional science content any more accessible. Aikenhead raises the critical issue of whose interests are served by compelling Melanie to construct new, but for her, irrelevant knowledge about heat. His answer is that it is not Melanie's interests that are being served. From the point of view of providing Melanie with knowledge that is helpful to her in understanding her everyday life, this is a reasonable interpretation. In Melanie's experience, the distinctions and definitions related to modern science conceptions of heat and temperature either do not make sense in terms of her other knowledge or are not significant (Cobern, 1998). This does not mean, however, that being able to reproduce these distinctions appropriately on examinations is not important, particularly in countries where performance on national examinations is crucial for continuing access to academic education. China is such a country (Gao, 1998; Wang, 1997;

Wang et al., 1996). The social system in which the students and teachers live and work cannot be ignored.

THE POLITICS OF REFORM

Efforts to reform science education to reflect the needs and aspirations of third-world and immigrant peoples must cope with the politics of education systems that are frequently hierarchical, resource poor, and highly competitive. Just as the development of new scientific facts and artefacts can be viewed as the construction of stable networks of human and non-human actors, so can the development of new educational programs (Gaskell & Hepburn, 1998; Nespor, 1994). A new program must build support by interesting a network of actors inside and outside the school system. These include social groups such as parents and students and post-secondary admissions officers. But the new artefact must also be able to be accepted within current technologies of assessment designed to choose who will carry on to the next level of education, and be workable within available budgets. In British Columbia, for example, efforts to implement a new program that involved fundamental challenges to traditional ways of valuing knowledge had to quickly accommodate to concerns about standards from advocates of traditional versions of scientific knowledge in the universities, a lack of money needed to fund the whole system at the same level as early successful pilots, the lack of widely accepted methods to assess new forms of practical knowledge on a provincewide, standardized scale, and the concerns of parents about the success of their children in post-secondary examinations in a society where the greatest status and future earnings are tied to occupations requiring a university degree.

Important decisions about enhancing minority science education must be seen as political as well as technical. The dramatic changes in school science curriculum that accompanied sweeping political changes at different times in China since 1949 are a good example of how different versions of school science are seen to represent different political and class interests (Liu, 1996). Developing science education policy means articulating the place and value of various minority groups' knowledge in the education system and in society at large. It means developing an understanding of what we mean by science and by school science. Minority peoples' knowledge about nature may not be modern science but it may have a place in school science. Discussions about the science curriculum, however, must take place within the context of the larger politics of education. In a system with centralized, national examinations, how different can local curricula afford to be even if there is increasing decentralization of curriculum decision making? Questions of audience must be attended to. Would the audience for a more "sensitive" science curriculum be minority students only or all students? If it were just minority students, is there a risk that these students and their knowledge would be further marginalized in relationship to the dominant culture (Cobern & Loving, 2001; McKinley, 1996)? Can minority knowledge be used for all students to illustrate ideas about the nature of science? Minority science education must provide a science education that works for minority students at many different levels.

These questions suggest the need to draw a wide range of people into a conversation about the issues (Stanley & Brickhouse, 2001). Do members of minorities feel that minority science knowledge is important to the survival of their culture? How important is this goal in relation to other educational goals and to the learning of modern science? Students' and parents' wishes and their positioning within both the school and society are important factors to consider. If there are issues of assessment, what kind of resources are available for developing new forms that can be managed within available resources?

These are both technical and political issues. There are no easy answers and what works in one cultural context will not necessarily work in another. Incorporating some traditional knowledge into the science curriculum may be one way of enhancing student self-esteem as well as providing a bridge to modern science. The ultimate question, however, is whether time spent on such activities can pay off in terms of the criteria for success that are most important to the students, parents, and teachers involved.

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