Who's Asking?

Native Science, Western Science, and Science Education

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As a young person, I feel blessed, humbled, and honored to be working toward improving our communities in this capacity. I am thankful to all those I have walked with and learned from and especially grateful for my elders, dear friends, and family who have helped and supported me on this road, especially Antonia Wheeler Sheehy, Pam Silas, Doug Medin, and Carol Lee. To my parents, siblings, grandparents, aunties, uncles, nieces, and nephews, thank you for making me who I am, and shaping how I think and how I dream for our communities. To the Chicago Indian community, thank you for being the testament to resilience and spirit. And to my loves Lawrence, Nimkii, Miigis, and Akina: chi miigwetch.

—MB

President Obama calls Michelle Obama "his rock." My wife, Linda Powers, is my rock.

—DLM

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Preface

We're going to start in the middle, and (to make things worse) we omit the beginning and the end. The beginning would take too long and the end is in the future, but this is a good point to pause and take stock.

The middle starts for Medin when Andrew Ortony suggested that Bang and Medin should meet. Bang was a Learning Sciences graduate student and (somehow) combined this with being director of education at the American Indian Center of Chicago. Medin was a professor of psychology and conducting research on mental models of nature on and around the Menominee reservation in Wisconsin. Bang was well acquainted with the Menominee Nation and Menominee people also make up an important part of Chicago Indian community.

Bang was interested in culture and learning and more specifically in science education and Medin in the role of culture and experience in children's understanding of the biological world. We talked, first about our separate interests and then about mutual interests. We ended up jointly teaching a course on research methods at NAES, Chicago campus (NAES = Native American Educational Services). There was also a NAES, Menominee campus, where Medin had taught, under the guidance of then-dean Karen Washinawatok. Eventually, we hit on the idea of a three-way research partnership involving NAES Chicago, NAES Menominee, and Northwestern University, and we were fortunate enough to receive a pilot grant from the Spencer Foundation to study culturally based science education (Karen Washinawatok was the NAES Menominee principal investigator).

This research partnership has survived some fairly substantial changes. For a variety of reasons, the Chicago component shifted to the American Indian Center of Chicago (AIC) and NAES, Menominee campus, became East–West University, Menominee Campus, before a further shift of the

partnership to the Menominee Language and Culture Commission. The pilot grant and a Spencer Foundation Fellowship enabled Bang to complete her dissertation (Medin served on her committee) and she completed a postdoctoral fellowship at the Chèche Konnen Center at TERC in Boston, while also continuing to serve as the AIC principal investigator. Meanwhile, Washinawatok left East–West to become tribal chair for a year before shifting to her current position as director of the Menominee Language and Culture Commission. In part because of his emerging interest in science education, Medin shifted from 100 percent psychology to a split between psychology and the School of Education and Social Policy (thanks to the generosity of the latter). Part of this shift brought into contact different methodological traditions that have become generative for us—that is, a combination of design research (a staple methodology of the learning sciences), cognitive and developmental research methods, and field methods for studying cognition in everyday practices and artifacts.

Another shift was that we were not doing simply culturally based science education research but rather culturally and community-based research. This shift was inspired by scholarship focused on education and indigenous knowledge systems by Native scholars like Dr. Gregory Cajete (whose important book *Native Science* became something of a handbook) and Dr. Oscar Kawagley, and by the AIC and Menominee community members who were the backbone for our research. At least it was a shift for Medin—Bang's second-year project in graduate school proposed community-based design as a strategy for design research that has been generative in the work we have done and currently are doing. This research has been supported by the National Science Foundation and by the Christian A. Johnson Endeavor Foundation.

As our projects continued to unfold, we increasingly saw the potential of combining developmental studies assessing biological cognition with observations on informal (out-of-school) science learning and design experiments aimed at putting what we were learning into practice and then reflecting on and evaluating these practices in the service of improved design. It was also evident that community- and culturally based science is not simply about knowledge and beliefs, but also is reflected in the most basic of science-related practices. We believe that Native science is not a historical science displaced by "modern" science, but rather a distinct perspective on doing science that is more relevant today than ever. More broadly

we believe that Western science has been, and is, seriously limited by the lack of diverse perspectives of practitioners of science and science education. As humankind continues to struggle toward a viable future for life on Earth, we have come to see these issues for science and its practitioners as among the most critical we face.

We are deeply indebted to many, many people for this project. Karen Washinawatok (Menominee) has been an advisor, partner, friend, and mentor at every step. Sandra Waxman has been a co-principal investigator and the brains behind many of our developmental studies, as well as a wonderful colleague and friend. Donna Powless* (Oneida) and Shannon Chapman (Menominee) welcomed us to the Menominee Tribal School, and Shannon was a principal investigator on one of our grants before becoming principal of the school. Pamala Silas (Menominee/Oneida), former CEO of the American Indian Science and Engineering Society and leader in the Chicago community, has been and is a fountain of wisdom and inspiration. Joe Podlasek (of LCO Ojibwe and Polish descent), president of the National Urban Indian Family Coalition and former executive director of the American Indian Center, has supported the work in the Chicago community. Cynthia Soto (Lakota/Puerto Rican) and Ananda Marin (Choctaw, African American, European American descent) have demonstrated ongoing leadership and kept us grounded throughout the course of our work. Most importantly, we both have benefited from the generosity and advice of elders, including more than a few who have passed on.

We acknowledge a debt to the community members at the American Indian Center of Chicago and on the Menominee reservation, including the members of the Menominee Language and Culture Commission. Any listing would be incomplete but we want to at the very least mention the following people who have either held important leadership roles or have deeply impacted the direction of our work: From the AIC: Jasmine Alfonso (Oneida/Menominee), Alexis Bellinger* (Ojibwe), Corey Brown, Julia Brownwolf * (Lakota), Jannan Cotto (Odawa/Ojibwe), Lawrence Curley (Ojibwe/Navajo), Alma Enriquez (Sioux/Chickasaw), Lori Faber (Oneida Tribe of Wisconsin, enrolled member), Gennafer Garvin (Ho-Chunk/Meskwaki), Tandy A. Garvin (Ho-Chunk Nation), Thomas Heaton (Lakota), Adam Kessel (Lakota/Italian descent), Mike Marin* (Navajo, Pueblo, Washo), Jennifer Michals (Potowatomi/Ojibwe), Mavis Neconish (Omaeqnomeniahkiw), Ashlee Pinto (Tunica-Biloxi), Heather Reed (Menominee), Raven Roberts*

(Potowatomi/Mi'kmaq/Ojibwe), Anthony Roy* (M'chigeeng First Nation), Skip and Babette Sandman* (Ojibwe), Angel Starr (Omaha/Odawa/Arikara), George Strack (Miami tribe of Oklahoma), Eli Suzukovich (Little Shell Band of Chippewa-Cree and Serbian), Deborah Valentino* (Oneida/Menominee), Sally Wagoner and Antonia Wheeler-Sheehy* (Blackfeet), and Negwes White* (Ojibwe, Navajo). From the Menominee Nation (Menominee unless otherwise noted): Amy Almadinger* (Ojibwe), Richard Annimetta, Liz Arnold, Chris Caldwell, Michael Chapman, Doug Cox, Carol Dodge, Robert Fernandez, Tony Fernandez, Julie Kaquatosh (Ho-Chunk), Tammy Lyons, Kateri Merino, Amy Miller-Cox, Connie Rasmussen (Oneida), Brett Reiter, Julie Schlichting, Glenda Tahmahkera, Mike Waukau, Rose Wayka, Stuart White (Menominee descent), Allen Washinawatok, Dot Wescott, Melissa Wescott, Sara Wescott. From Shawano Wisconsin: Tina Burr and Kay Fredrick.

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1 Introduction: Who's Asking?

"Researcher 'diversity'—this is a showstopper for me."

That opening comment needs a bit of explanation. It comes from a friend and outstanding scholar who has done pathbreaking cultural research. The context was a team of us writing a short essay to the National Science Foundation (hereafter NSF) on why the behavioral and social sciences should have a strategic priority of increasing the range of their study populations.

Why this priority? Because broad claims about human psychology and behavior based on very narrow samples from Western societies are regularly published in leading journals. An analysis of the top journals in six subdisciplines of psychology from 2003 to 2007 (Arnett 2009) revealed that 96 percent of participants were from Western industrialized countries. These samples also reflect the country of origin of the authors—99 percent of first authors were at universities in Western countries. Furthermore, studies with adults are largely studies of college students attending these same universities and studies with children are largely drawn from the middle-class communities that are close by.

Of course, this narrowness of samples may not be a problem if people are pretty much the same the world over. But cross-cultural studies show that claims about basic cognitive processes derived from studies with undergraduates often do not generalize well to other populations (Atran and Medin 2008). In fact, a recent extensive review of cultural comparisons involving a wide range of phenomena including visual perception, judgments of fairness, categorization, spatial cognition, memory, moral reasoning, and self-concepts (Henrich, Heine, and Norenzayan 2010) strongly suggests that these "standard" research participants actually may be unusual or "outliers" compared with the rest of humankind.

That was half of our argument to NSF. The other half was about the diversity of scientists carrying out the research. We argued that diversity was a good thing, not solely on grounds of fairness and equity, but also because science would be the better for it. That was the showstopper for the person quoted above.

And he wasn't the only one. Although support for study population diversity was essentially universal among the researchers we approached (this may reflect our choice of who to approach), researcher diversity was much less enthusiastically received. One fellow researcher commented, "I would not add diversity of experimenters in here, because I think it is distracting," and another suggested that "the diversity requirements currently in place have turned into a burden on investigators with no positive impact on anything, so I am not keen on more of those efforts to increase diversity."

Here's another related story. During the year when Carol Lee was president of AERA (American Educational Research Association), Medin and Lee approached the editor of *Science* magazine, proposing that we contribute an editorial on the need for diversity in science. Our proposal was initially accepted and we were given a target date for submission. Our thesis was, as previously noted, that diverse science makes for better science. After we sent in our editorial we did not hear from *Science* for months and months. Finally we inquired and were told that the feeling was that the topic of diversity was a bit "shopworn and stale" and that perhaps they would get back to us sometime in the future. Again, apparently a showstopper. Of course there's also the possibility that what we had written just wasn't very good.

Is there any connection between researcher diversity and the effectiveness of scientific research? Our friends certainly are divided. The scientist for whom diversity was a showstopper went on to elaborate his argument: "Economics is filled with Indians, Europeans, Latin Americans, and East Asians. It's much more diverse than psychology. The most important young economist in the world today is Turkish (MIT). Is economics better theoretically for it? (If your answer is 'yes,' how?) Anthropology did affirmative action for PhDs a long time ago. Grad students are recruited from everywhere. Mostly, they apply postmodernist critiques to their hometowns. Lots of diversity, no scientific progress."

The preceding observation may be accurate if the students who succeed in the sciences are only those who buy into the majority, Western

orientation toward their discipline.[1] But as we'll see later on, there are important exceptions to this notion.

Elissa Newport, a close friend (of Medin's) and a psycholinguist, had a very different take on things. She wrote, "I didn't answer your previous email earlier only because I was trying to figure out if there was an easy way to broaden the letter a bit, to include a couple of diversity issues close to my own heart—including sign languages and deaf communities as equally important for study as spoken languages (at the moment everyone studies spoken languages, and then the specific investigators who work on sign languages do that as a special topic), and also as emphasizing training native members of other languages and cultures so that they can be the ones who do research on their own culture or be the ones who collaborate on such studies (in the sign language field, most labs have some underling who is deaf and employed as a lab tech, but very few researchers [like Ted] are actually trained and working in the field)." (Ted is a deaf psycholinguist and Elissa's husband.)

Aside from supporting diversity as a matter of equity, does scientists' diversity really matter? We think that it does. It matters because it touches on key issues of the relation between science and society, between science as authority and public policy, and, as we will see, because it raises foundational issues for science education, especially for students of color. These claims are not obvious, and it will take some time for us to develop our arguments and to support them.

To examine the relationship between researcher diversity and science we have to examine the nature of science more closely. Although it is a bit of a caricature, we will contrast two competing narratives about science. In one corner we have the view that science is objective, value-neutral, and acultural. Although individual scientists may have biases, the sociology of science and the associated competition of ideas lead science eventually to truth.

Furthermore, it doesn't matter how a scientist would like the world to be; what counts is how it is, and that's what science aims to discover. This grounding in the world ensures the unity of science. Although there are always scientific disputes, scientists believe that there is one correct account of how things are in the world (and what makes it correct is that it *is* how things are). In short, (the nature of) science is settled.

Some people in this corner also are fond of the story of the development of science according to which it basically started in Greece, was nurtured

in Europe during "the Enlightenment" and the associated triumph of reason, and eventually grew into modern science (a.k.a. "Western science"). Only in the West has science been cleanly severed from the irrationality of magic and superstition. That's the gist (a.k.a. stereotype) of the first narrative.

In the other corner are scholars who question all of these claims. There's more variability of opinion in this corner, but membership tends to include the following other claims. Scientists do not shed their cultures at the door and their practices reflect their culture's values, belief systems, and worldviews. Unity of science is not assumed—scientific models, theories, and representations highlight some aspects of reality but may ignore or conceal others. On this pluralistic view, different theories of the same phenomena may be useful for different purposes (like wave versus particle theories of light). In this view, each theory is only a slice or perspective, and different aspects of reality may be relevant to them.

Some in this corner see a science dominated by white males as limited in its perspective, and consequently they are supportive of researcher diversity. (A few see white male science as biased and incorrect, but the majority just sees it as [potentially] different and limited.) Finally, the history of science they tell is not nearly so Eurocentric and triumphalist in its tone.

Many contemporary scientists find themselves in conflict. The unity of science / one truth / no bias position sounds unrealistic, even as an ideal (can there be a science that expresses or reflects no values?). But the other position seems to go too far—can it rule out creation science and other pseudosciences as meeting the standards for science? So scientists may consider themselves to be facing a choice between an unrealistic ideal and something of an "anything goes" Pandora's box.

Our opinion is that contemporary science and science education are being held back by this pattern of dichotomous thinking and defensiveness. Many potential scientists are turned off by the prospects of a science without values and approaching nature from a remote, dispassionate perspective. This sort of science is sometimes not obviously relevant to their daily lives or fails to satisfactorily meet pressing needs. These feelings may be especially salient for minority scholars who feel a responsibility to "give back" to their communities.[2] The same can be said for science education, which also treats science as settled. But maybe we're getting ahead of ourselves.

What This Book Is About

So far we've talked about the culture of science (or its presumed cultural neutrality), but equal focus is on the science of culture and its implications for science education. We see the culture of science and the science of culture as closely intertwined, as two sides of the same coin. Recent National Research Council reports have emphasized the idea that formal science education will be more successful if it can take advantage of the science learning that takes place in informal contexts, outside of school (Bell et al. 2009). There is substantial evidence, some of which we will describe in detail later on, supporting the idea that children come to school with knowledge, orientations, values, and practices that are relevant to science learning and that reflect their own culture. When these orientations are supported, students are more engaged, identify with, and are more successful with science than when these orientations are ignored or discouraged (Bell et al. 2009; Bransford and Brown 2000).

How are things working in the United States at the moment? The answer is not very well for anyone, and especially not very well for U.S.-born students of color. Although the demand for science and engineering workers has been growing very rapidly, the supply has been extremely limited. The growth in science and engineering doctorates awarded in the U.S. over the past decade has almost exclusively been driven by increases in foreign students. As noted in the National Academy of Sciences report *Rising above the Gathering Storm* (National Academy of Sciences et al. 2007), in the year 2000 the United States ranked twentieth out of twenty-four countries in the percentage of 24-year-olds who had earned a first degree in the natural sciences or engineering. That report recommended setting the goal of increasing the percentage of 24-year-olds with these degrees from 6 percent to at least 10 percent, a standard already met or exceeded by many of the other twenty-three countries. The United States will be less competitive globally if fails to develop or otherwise limits the pool of S&E (science and engineering) scholars.

Let's introduce a demographic twist on this goal. People of color represent a significant segment of the US population (about a third), and this segment is projected to grow substantially, such that the United States will likely have a majority-minority population by mid-century. If S&E degrees are going to grow from 6 percent to 10 percent, then much of that growth

will need to come from minority scholars. In the words of the 2010 NAS report *Expanding Underrepresented Minority Participation*, "This growth rate provides an opportunity as well as an obligation to draw on new sources of talent to make the S&E workforce as robust and dynamic as possible."

This same report lays out the current sobering picture with respect to underrepresented minority participation in S&E ("underrepresented minority" does not include Asian Americans, who are the most overrepresented group in S&E). To quote from that report:

> But we start from a challenging position: underrepresented minority groups comprised 28.5 percent of our national population in 2006, yet just 9.1 percent of college-educated Americans in science and engineering occupations (academic and nonacademic), suggesting the proportion of underrepresented minorities in S&E would need to triple to match their share of the overall US population.
>
> Underrepresentation of this magnitude in the S&E workforce stems from the underproduction of minorities in S&E at every level of postsecondary education, with a progressive loss of representation as we proceed up the academic ladder. In 2007, underrepresented minorities comprised 38.8 percent of K-12 public enrollment, 33.2 percent of the US college age population, 26.2 percent of undergraduate enrollment, and 17.7 percent of those earning science and engineering bachelor's degrees. In graduate school, underrepresented minorities comprise 17.7 percent of overall enrollment, but are awarded just 14.6 percent of S&E master's and a miniscule 5.4 percent of S&E doctorates. Only 26 percent of African Americans, 18 percent of American Indians, and 16 percent of Hispanics in the 25–29-year-old cohort had attained at least an associate degree.
>
> But again, the statistics are even more alarming for underrepresented minorities. These students would need to triple, quadruple, or even quintuple their proportions with a first university degree in these fields in order to achieve this 10 percent goal: at present, just 2.7 percent of African Americans, 3.3 percent of Native Americans and Alaska Natives, and 2.2 percent of Hispanics and Latinos who are 24 years old have earned a first university degree in the natural sciences or engineering.
>
> Recent data from the Higher Education Research Institute (HERI) at UCLA shows that underrepresented minorities aspire to major in STEM [science, technology, engineering, mathematics] in college at the same rates as their white and Asian American peers, and have done so since the late 1980s. Yet, these underrepresented minorities have lower four- and five-year completion rates relative to those of whites and Asian Americans. That a similar picture was previously seen in data in the mid-1990s signals that while we have been aware of these problems for some time, we, as a nation, have made little collective progress in addressing them. (National Academy of Sciences et al. 2010, 3–5)

As the report goes on to note, this gloomy picture is still worse if we consider who is able to obtain research grants from agencies like the National

Institutes of Health (NIH) and the National Science Foundation. The figure of 6.8 percent of doctoral scientists who are minorities (again, non-Asian) shrinks to about 3 percent when it comes to NIH and NSF funding for research.

The Specific Case of Native Americans

Since Native Americans will be the main minority group that we will focus on in this monograph, we will take the time and space to describe their corresponding statistics on underrepresentation in further detail. For Native Americans the picture we have presented remains accurate or is even more extreme. There is chronic underrepresentation of indigenous people in science-related fields. Native Americans drop out of high school at the highest rates of all ethnic groups in the continental United States, and only about 6 percent receive bachelor's degrees (National Academy of Sciences et al. 2007; Pavel and National Center for Education Statistics 1998).

Nowhere is the problem more apparent than in science learning. For example, between 1997 and 2007, Native people represented an average of 0.63 percent of the total number of bachelor's degrees and an average of 0.48 percent of the doctorates awarded in science and engineering (National Science Foundation 2007). The 2010 census found that about 1.7 percent of the U.S. population identified themselves as American Indian or Alaskan Native. Thus, these figures indicate that Native people are substantially underrepresented at the college level and even more underrepresented at the doctoral level. Even without taking into account the age distribution of Native Americans, the number of doctoral degrees would need to more than triple to be proportionate. Considering that the Native American population has many young people (especially compared with the aging U.S. European American population), a more accurate figure might be four or five times the present rate.

These figures are relevant to the broader picture of minorities in STEM (science, technology, engineering, mathematics) disciplines, but they are especially relevant to Native nations who are confronted with environmental and resource management issues and sometimes are forced to rely on outside expertise from people who may not share their values or have the cultural and historical understandings needed to provide effective advice. These shortages are equally relevant to urban Indian communities as they

also face issues where STEM expertise is needed, not only in the health and medical sciences but also in environmental policy debates.

The shortage of degreed expertise within Native communities contributes to and perpetuates struggles with education and educational achievement, adequate economic development, the enhancement of community health, and community-based governance of resource management. To improve the circumstances that affect indigenous communities in ways that are likely to have a sustained impact requires that we improve the educational experience and attainment of Native peoples, especially within STEM education.

Although there are important general questions concerning how to foster educational achievement, there is reason to think that some of the difficulties are specific to science education. Here is an example from the Menominee reservation in Wisconsin where we have conducted research for the last fifteen years. A 2005 report of statewide, standardized tests indicated that in fourth grade Menominee children scored above the national average in science and it was their best subject; by eighth grade, however, Menominee children scored below the national average in science and it was their worst subject (see Bang, Medin, and Atran 2007; Grigg, Lauko, and Brockway 2006). These striking findings could be interpreted in a number of ways, but we think they indicate that the orientations toward the natural world that Menominee children bring to the classroom are not clearly reflected and supported in science teaching.

In our view problems with achievement are more complicated than simply knowing or not knowing "science content" (see Demmert and Towner 2003 for a review of studies with Native American populations). Instead, the key issue might be "who owns science?" If science is seen as or implicitly operates as a franchise owned and operated by white people, then minority students may well not identify with science or see it as relevant to their lives.

So let's sum up for a minute. There is something about the educational experience of minorities that leads to a situation where minorities are severely underrepresented in STEM fields. This does not appear to arise from differences either in initial abilities or initial interest. We think that one factor in this underrepresentation derives from a clash (where the clash takes multiple forms) between the cultural values, orientations, and practices of minority students in general, and Native American students in particular,

and the cultural values, practices, and orientations currently privileged in science education. This is why we believe that it is critical to understand the cultural orientations and practices that children bring to the classroom, and why we need a more robust science of culture, especially with respect to cultural orientations toward the natural world. As we mentioned before, that's one side of the coin.

On the other side of the coin, participation in science is limited by the common presumption that science is intrinsically acultural and value-free. This stance could help explain why students in general seemed to be turned off to science and engineering (see Aikenhead 2006). In Medin's decades of contact with Northwestern University undergraduates he has often encountered students who are planning to go to medical school, and they often have a story to tell linking their commitment to some situation involving a relative or close friend confronted with a medical condition. Medin has *never* had an undergraduate majoring in a STEM discipline tie their commitment to any real-world problem, though the recent upsurge of interest in environmental sciences may change that.

We believe, however, that this side of the coin is actually a science reflecting the cultural values of its practitioners, not some "neutral" science. From our perspective it is critical to examine each side with respect to the other—we believe that we cannot deeply improve science learning and identification with science (side 1) without querying science and science education as a set of cultural practices (side 2).

With respect to science learning there are once again two competing narratives. One sees science as some objective thing, and assumes either implicitly or explicitly that cultural/ethnic differences in learning and taking up science have nothing to do with the science side and everything to do with the cultural side. According to this perspective, one might do culturally based research from the point of view of identifying barriers to (minority) participation in science, such as unequal access to resources or lack of role models.

An example of this orientation may be the NAS report on increasing minority representation in science and engineering that we cited earlier. It made the following recommendations:

> (1) prepare America's children for school through preschool and early education programs that develop reading readiness, provide early mathematics skills, and introduce concepts of creativity and discovery; (2) increase America's talent pool by vastly

improving K–12 mathematics and science education for underrepresented minorities; (3) improve K–12 mathematics and science education for underrepresented minorities overall by improving the preparedness of those who teach them those subjects; (4) improve access to all postsecondary education and technical training and increase underrepresented minority student awareness of and motivation for STEM education and careers through improved information, counseling, and outreach;[3] (5) develop America's advanced STEM workforce by providing adequate financial support to underrepresented minority students in undergraduate and graduate STEM education; and (6) take coordinated action to transform the nation's higher education institutions to increase inclusion of and college completion and success in STEM education for underrepresented minorities. (National Academy of Sciences et al. 2010, 171–181)

These laudable recommendations illustrate the point that cultural differences in participation in science do not necessarily lead to a deficit model (as in "What's wrong with these people that makes them unable or unwilling to become scientists?"). Note also, however, that the NAS report does not query science itself, or the practices associated with it.

Here's the competing position. The practices associated with science and science education reflect the cultural values and orientations of the practitioners. Thus the answers to scientific questions depend on who's asking, because the questions asked and the answers sought depend on who's asking, even when all parties adhere to rigorous research methods. We are not claiming that science is subjective, but rather that scientific practices embody values and perspectives, and these values and perspectives may vary across factors like gender, social class, and culture.

Participation and achievement in science are mediated by a complex set of sociocultural factors not often recognized in such science equity efforts. A certain claim is that one's social world and context shape values, skill sets, and expectations (Nasir and Hand 2006). Thus, the act of exposing all individuals to the same learning environments does not result in science equity, because the environments themselves are designed in a manner that supports the cultural repertoire of the dominant culture. (We'll have quite a bit more to say about this in later chapters.) Because of this neglect of cultural issues, science instruction may often privilege and support the science-related practices of middle-class European Americans and frequently fails to recognize the science-related practices associated with other groups (Bang et al. 2012; Lee and Fradd 1998; Lemke 1990; Moje et al. 2001; Nasir and Hand 2006; Warren et al. 2001). In other words, traditional

approaches to science education reflect cultural assumptions and framework theories that may be alien to students and scholars of color.

Ballenger and Rosebery (2003) note that educators often hold stereotyped notions of what counts as scientific reasoning and privilege a subset of sense-making practices at the expense of others. For example, scientists regularly use visual and discursive resources whereby they place themselves in physical events and processes to explore the ways in which they may behave (Ochs, Gonzales, and Jacoby 1996; Wolpert et al. 1997). Yet these same practices often are not recognized as useful or a part of science in the classroom, and this lack of recognition has the effect of marginalizing students' home discourses (Rosebery and Hudicourt-Barnes 2006). These and other findings undermine the view that professional scientific practices are largely disassociated from forms of experience and practice in the everyday world (Warren et al. 2001).

This competing narrative requires that researchers examine the *relationships between* cultural practices and values that children bring to the classroom and the cultural practices associated with science and science education. A more conservative position might be to argue that the key is not science per se but rather science education practices. The argument would be that science instruction emphasizes those practices that are common in white middle-class communities, if only because the teachers themselves typically are white and middle-class. One example of these practices, not specific to science learning, is the IRE (inquiry-response-evaluation) form of interaction (What do we breathe out? Carbon dioxide? Right!). IRE is commonly used in classrooms, and anyone who has spent time in middle-class communities will recognize that it is also common outside of school. Hence it is a form that middle-class children are familiar with before they enter school. In other cultural communities it may be strange to have knowledgeable adults ask children questions that the adults already know the answers to. Although we agree that science education practices are critically important, we reject this conservative view in favor of the claim that we must query science itself.

Overview

Our plan for this monograph is as follows. Our overall thesis is that scientist diversity provides new perspectives and leads to more effective science. We

will briefly review the history of science, primarily to critique the view that science had its unique origins in the West. As part of the analysis of the cultural character of science practices we will also take up some arguments and evidence from feminist science (we could and perhaps should have been mentioning gender all along, as science often appears to be the province of men) and from studies of the sociology of science from a cross-cultural perspective. Furthermore, we will suggest that the sciences may well need a pluralistic account and that there are compelling reasons to doubt the unity of science.

The heart of our monograph is a case study of Native American and European American orientations toward the natural world. This is intended both as a concrete example of how culture affects science-related practices and as an application to science education. We will argue that Native Americans and European Americans manifest distinct ways of situating themselves with respect to the rest of nature, ways that are both explicitly articulated and implicit in practices. These differences are consistent across a wide range of converging measures and evident in children as well as adults.

In a nutshell, the European American model sees humans as separated from nature and the Native American model sees humans as a part of and living in relationships with the rest of nature. We will argue and provide evidence that these differences in epistemologies have wide-ranging implications for science-related values and practices.

Then we turn to our efforts to develop culturally and community-based science education programs, in both a rural and an urban context (on the Menominee reservation in Wisconsin and at the American Indian Center of Chicago). These efforts provide something of a testimonial for our arguments. Along the way we will necessarily take up the history of Indian education in the United States and a series of methodological and ethical issues associated with research in tribal contexts. Although our story is complicated and the forms of evidence wide-ranging, we believe that the overall picture is clear and compelling in its account of the culture of science and the science of culture.

To make our story a bit more clear and coherent we'd better say something about who we are. Dr. Megan Bang is Professor of Learning Sciences and Human Development at the University of Washington. On her mother's side she is Ojibwe and on her father's side Italian. Until recently, she

was a longtime member of the Chicago Indian community. Formerly she was Director of Education at the American Indian Center of Chicago (AIC) for more than a decade. At the AIC she co-founded a very effective tutor/mentor program, named Positive Paths. These professional experiences motivated her to return to graduate school where she met Medin. She earned her PhD in learning sciences at Northwestern University. In part, the inclusion of the urban intertribal Chicago community in our research evolved because Bang attended graduate school and Medin served as one of her advisors.

Although Bang had personal relationships with various members of the Menominee Nation prior to graduate school, as a graduate student she became professionally involved with the Menominee Nation through Medin and has now been working with the Menominee community for the past nine years. This has been coupled with continuous involvement with the AIC community and Bang has been the AIC principal investigator on several grants. Bang has taught at Northwestern University and Bang and Medin have co-taught a course at NAES (Native American Educational Services), Chicago campus. Bang has been a respected leader in the Chicago Indian community and, in Medin's view, has a special gift for empowering others.

Douglas Medin is Professor of Psychology and of Education and Social Policy at Northwestern University. On his father's side he is Swedish and German and on his mother's side Scottish and French. He is fond of saying that he has gone from being a first-rate cognitive psychologist to being a second-rate cultural anthropologist, before assuming his present role as a third-rate educational researcher. The subject matter correlates of these shifts go from the psychology of concepts, to studies of culture and cognition, to efforts to engage community-based science education both at the AIC and on the Menominee reservation in Wisconsin.

Medin has formed many relationships with Menominee elders, adults, and youth over these years, participated in many community events, and has supported and worked on community issues outside of research projects. Since these projects began Medin has established a similar relationship with the Chicago intertribal community and until recently served on the AIC board of directors. He has taught courses at NAES, Chicago campus; NAES, Menominee campus; and the College of the Menominee Nation.

Andrew Ortony, professor in the Northwestern School of Education and Social Policy, introduced Bang and Medin when Bang was a learning

science graduate student. We soon found that we were kindred spirits and started working together at NAES, Chicago campus, the Menominee reservation, and then the AIC. Indeed we've worked together for more than a decade and been co-principal investigators on a fair number of grants. This monograph is one outcome of our collaboration. Working together closely and well makes relative contributions invisible and each of us has great respect for the other. We are also respectful and humbled by the individuals and communities that have helped us every step of the way.

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