Innovations in Culturally-based Science Education through Partnerships and Community[1]

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I. Introduction.

In what follows we describe a program of educational research aimed at improving science achievement among Native American children. This ongoing project builds on previous work but is distinctive in two ways. First, it involves a coalition of community members and teachers developing science curricula. Second, it represents the cooperative efforts of reservation-based tribal institutions, an urban tribal institution and a major research university. On numerous grounds this is an unlikely combination, so the synergies growing out of this project will repay careful attention.

II. Background.

Our long-term goal is to improve science learning and school achievement for Native-American children. Student achievement in science education is a well-rehearsed problem, particularly for those groups of children who have historically been placed at risk. This problem is particularly acute with Indigenous populations. The high-school graduation rate is at just 51.1% for Native youth (Orfield et al, 2004). Only 6% of the population that does go on to college receives a bachelor's degree (NSF, 2007; Pavel et. al, 1998). Nowhere is the problem more apparent than in science learning. Over the past ten years, Native people have represented an average 0.63% of the total number of bachelors degrees and an average of 0.48% of the doctorates awarded in Science and Engineering (NSF, 2007), The 2000 census found that about 1.5% of the US population identified themselves as American Indian or Alaskan Native. Thus, these figures indicate that Native people are about 60% under-represented at the college level and 67% under-represented at the doctoral level (even without taking into account the younger age distribution of Native-Americans).

To make these numbers more concrete, over the past 10 years a total of only 14 doctorates have been awarded to Native scholars in Computer Science, 10 in Physics, 5 in Astronomy, 3 in Ocean Sciences, and 1 in Atmospheric Sciences (NSF, 2007); in the biological sciences, 108 doctorates have been awarded to Indian scholars. Yet these numbers only represent 0.3% of the total number of degrees awarded (NSF, 2007). These numbers represent an increase in representation from earlier decades, albeit a minimal one.

The issue of achievement in STEM (science, technology, engineering, math) fields is far more significant than just a matter of representation; it centrally involves power, particularly in light of real socio-scientific problems facing the world – such as global warming and other environmental issues. The lack of degreed expertise within Indigenous communities contributes to, and perpetuates, struggles with sovereignty and survival, education and educational achievement, economic development, the enhancement of community health, community-based governance of resource management, and the cultural vitality of Native communities. In short, Native people

both on and off reservations continue to struggle for cultural and sovereign survival. 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 people, especially within STEM education.

Understanding the widespread lack of achievement in STEM education and developing possible solutions poses critical challenges, in light of cognitive science research, and community-based research, which suggest that the problems with achievement are more complicated than simply knowing or not knowing "science content" (see Demmert and Towner, 2003, for a review). A growing body of educational research is demonstrating the need to understand the complexities that (culturally) diverse ways of knowing create for teaching and learning environments, particularly if we are to improve school achievement for those groups of students who have historically been placed at risk (i.e. Warren et al, 2001; Gutierrez and Rogoff, 2003; Gutierrez, 2006).

III. Challenges to and the Need for Innovation.

We are far from the first to point out the under representation of Native scholars in science and science education. But there are a number of significant barriers to progress in addressing these issues. First of all, we are not optimistic that large scale studies of the correlates of achievement will provide constructive advice. We see three problems with this approach: 1. It reifies the status quo because innovations will likely be buried in the noise after large scale predictors are regressed out, 2. The large scale factors are likely to be variables such as family income, parent formal education and number of books in the home, variables that are difficult to turn into interventions, except for the implicit, pernicious suggestion that everyone should be white and middle class, and 3. The units of analysis (e.g. Native Americans) are often too broad to reveal the relevant dynamics (see Chandler and LaLonde, 1998 for a compelling example involving suicide rates among First Nations peoples of British Columbia).

A second barrier to constructive engagement of science education research with Native communities is the physical, social, historical, and power distance between major research universities and tribal institutions. Universities tend to be in urban areas and though more Native Americans live off reservations than on them, Indian children are usually scattered throughout urban schools and an Indian child is often the only Native-American in the classroom. Although the more recent development of tribal colleges and universities is a positive development, the primary mission of these tribal institutions has been education, not (educational) research.

A third barrier (or perhaps an amplification of the second) is the status of both education and research in tribal communities. We will not rehearse the boarding school era and the enduring historical trauma associated with it and other assimilationist efforts that have been integral to schools and schooling. Perhaps it suffices to say that the history of formal education in American Indian communities documents the consistent attempts to undermine the sovereignty, as well as cultural and intellectual vitality of Indigenous peoples. Control over the education of Indigenous children and even the parenting of Indigenous children was systematically and intentionally manipulated as a way to "solve the Indian problem."

Although the most pernicious aspects of the boarding school era have been confronted and displaced, they have been replaced by more subtle, but ultimately equally

damaging, power structures that organize learning in terms of the values and practices of the dominant culture. The everyday practices of teaching and learning have not been in the control of or in many cases even implemented by Indian people. For many community members, memories of school are very unpleasant. Although they wish for their own children to have better experiences, it is hard for them not to conceptualize schools as a "necessary evil," let alone as a positive resource for community values.

There is a corresponding history of exploitation in research conducted in Indian communities. The polite expression of this attitude is the belief that "we have been studied too much." More analytic responses point to the unequal benefits of research----- the Indian informants get coffee and donuts and the graduate student researcher gets a PhD or the Professor gets a book published. And with annoying frequency, the research report is disparaging of the community being studied. Who needs that?

In summary, there are very significant barriers to efforts to address under-representation in science and science education in Native-American communities. Pretty clearly significant changes in orientations and innovations are needed to address them. On the other hand, we could be accused of failing to recognize the significance of the development of tribal colleges and universities and other efforts of tribal entities to assert sovereignty. As will be seen, however, we embrace both perspectives.

IV. Innovation: Partnerships and Communities.

Overview. Our project is a collaborative effort involving Northwestern University, TERC, the American Indian Center of Chicago (AIC), and various institutions on the Menominee reservation in Wisconsin, including the Menominee tribal school and the Menominee Language and Culture Commission. We began by describing our current interdisciplinary research team and then give a brief history of our collaboration.

The majority of our research team consists of Native-American educators who have close ties to the communities being studied. Bang, Director at the American Indian Center of Chicago, has been a member of and working in the Chicago Indian community for more than twelve years, and has been working with the Menominee community for the past seven. Washinawatok has a lifetime of experience on the Menominee reservation, having served as Tribal Chair, as a member of the Tribal Legislature, as Dean of NAES College (Native American Educational Services), Menominee campus, and she has been a research partner for the past five years. She is currently Director of the Menominee Language and Culture Commission and a member of the Menominee Indian School District Board. Chapman is lifelong member of the Menominee community, has been a logging contractor, and is currently Assistant Principal at the Menominee tribal school. Chapman has recently replaced Carol Dodge, who took over the Menominee component of this project when Washinawatok was serving as Tribal Chair. Medin (Northwestern) has worked with the Menominee community for more than twelve years and with the Chicago Indian community for seven years. He has taught courses at NAES, Chicago campus, NAES, Menominee campus, and the College of the Menominee Nation. More recently teachers and researchers associated with the project have been able to receive Northwestern graduate and undergraduate credit for courses offered by Medin at the AIC and on the Menominee reservation.

Our collaboration has been designed to be an equal partnership. Rather than

having Northwestern University control all research funds or having Northwestern as the primary institution issuing subcontracts to tribal entities, whenever possible we have sought to submit grants with a single project description and three independent budgets, independently administered. Our goal is also to match the budgetary sharing with equal sharing in research design and evaluation, taking into account the different skills collaborators bring to the project. Shortly, we will provide a bit more by way of the history of our collaboration but first we briefly describe the community component of our project.

Our project has two other crucially important goals: 1. to strengthen the capacity of Native communities to improve student learning and achievement and 2. to increase Native undergraduate and graduate student participation in research. In our previous work we have actualized these goals in two ways: through a general process of collaborative praxis that builds the research skills and administrative infrastructure within Indian communities and through a collaborative design process we have been developing and refining. We call this design process *community-based design* (CBD), the foundation of which rests on the comprehensive participation of community members, including teachers, elders, parents, community experts, researchers, and youth in all aspects of the research, including the conceptions of the problems, project design and implementation, data collection and analysis.

The above description offers a snapshot of our research partnership and goals. The remainder of this chapter is organized as follows. We first describe the benefits of our partnership by outlining how it addresses the barriers outlined above. In doing so, we will need to provide more background information. Next, we provide some examples of our community-based design in practice and its effects on the communities. Then, we briefly outline more of the history of our project, because it may be relevant to other efforts at forging research partnerships. Finally we summarize with lessons we have learned from our partnership.

V. Research in Indigenous Communities: Background and Organization

Since the 1970's there has been a growing effort for Indigenous people to be running schools in Indian communities. Most of the progress made on this front, however, has been at the administrative level, not at the classroom level. The majority of Indian children both on and off reservations have non-Indian teachers. The design of this research project recognized this and intentionally proposed engaging teachers and community members in the design of a learning environment integrating levels of classroom, content and pedagogy. The intent was to begin to create a space where community members engaged in reclaiming the classroom level of teaching and learning for Indigenous children (Smith, 1999).

The design of our methods has been based on an understanding of appropriate research methods for working with American Indian communities. There is a long history of research in American Indian communities that has often not been in their best interest, a legacy that has made many Native communities suspect of research. Over the years indigenous researchers themselves have worked to develop appropriate methods and criteria for conducting research (Hermes, 1999, Smith, 1999, Mihesuah, 1998, Guyette, 1983). There are some general lessons that have driven the approach to this work. First, all of literature generally agrees that the *participatory action research (PAR)* is the best

framework of inquiry. PAR has generally been defined as an integrated approach that relies on the participation of community members to investigate the issues at hand while building local skills for the purpose of increasing autonomy through a process of praxis (Hermes, 1999). PAR includes the following criteria: elder input, use of traditional language, community participation in research agenda, staff selection, and budget, community payoff, respect of cultural value, and informed consent (Hermes, 1999, Hudson & Taylor-Henley, 2001). Additionally, when conducting research with reservation communities, investigators must go through the tribal IRB process; an IRB approval from a mainstream institution is not sufficient (Lomawaima, 2000). Although less has been written about working with urban populations, and the benefit of tribal approval of the research is not possible, forming a local advisory committee within the community and seeking institutional support of local organizations is a good idea. Our work reflects these criteria and approaches.

Research context and communities involved**.** Our 3-way partnership is not two 2-way partnerships with one partner common to both. Although we describe the Menominee and Chicago Indian communities separately, both communities have worked together with AIC members coming to the Menominee reservation and Menominee community members coming to the AIC for collaborative meetings.

Menominee community. The Menominee are the oldest continuous residents of Wisconsin. Historically, their lands covered much of Wisconsin but were reduced, treaty by treaty, until the present 95,000 hectares was reached in 1854. There are 4-5000 Menominee living on tribal lands. Over 60% of Menominee adults have at least a high school education and 15% have had some college. The present site was forested then and now - there are currently about 88,000 hectares of forest. Sustainable coexistence with nature is a strong value (Hall & Pecore, 1995). Hunting and fishing are important activities and children are familiar with both by age twelve.

The Menominee children in our project attend a tribal school. The tribal school serves K-8 and has approximately 400 students in the school. Although exposing children to the Menominee language is an important focus of the tribal school, the vast majority of science instruction and everyday discourse is in English.

Urban Indian population. There are approximately 40,000 Indian people in Cook county, many of whom were relocated to the area during the 1950s and 60s during the federal relocation era. The Chicago community is a very diverse intertribal community with individuals representing more than 100 tribes across the country. Native-American children are scattered across a number of schools in the district and are a minority in every classroom.

The AIC is the oldest urban Indian center in the country and serves as the social and cultural center of the Chicago Indian community. Menominee and other Wisconsin tribes are well represented at the AIC. The Chicago Indian community faces many of the same problems that other inner city communities face, such as high rates of poverty, lack of access to quality healthcare, poor schooling options, low employment rates, issues surrounding drugs and alcohol and high rates of violence.

VI. The Design Process: the Early Stages

The project idea was presented to community members as a critical need in the community. There were three primary kinds of issues that were mentioned at the start.

The first was the serious need for more Indian people in STEM fields. We did a quick survey of STEM related positions across several Indian nations and the majority of them were filled with non-Indian people, including on the Menominee reservation. This was framed as fundamentally an issue of sovereignty because it meant that non-Indian people had a powerful influence on the use and strategic direction of natural resources in tribal communities.

The second issue was the achievement statistics at various levels, including advanced degrees all the way down to state standardized tests. Our previous examination of standardized tests found that Menominee children in Wisconsin test better in science in the fourth grade than any other subject but by 8th grade it is their worst subject (Bang et. al, 2007). It is important to note that performance on other subjects stays stable across time, suggesting that there is something unique going on in science. We coupled this framing with cognitive research we had conducted with Indigenous children, Menominee included, in which basic biological concepts and reasoning patterns were examined (e.g. Ross, et al. 2003, Bang, et al, 2007). The general findings from these studies suggest that Native children come to school with advanced understandings of biology, that their reasoning patterns mirror those of practicing scientists, and further that Menominee fishermen tend to organize knowledge and reason along ecological rather than taxonomic lines (Medin, et al, 2007). We suggested that this was potentially a deeply productive intellectual asset that schools fail to mobilize or recognize.

The last piece of "evidence" that was used to frame the introduction to this project was a brief survey of science classroom materials we conducted in which we looked at the way content was organized. We found that the systems level analyses in general and the coverage of ecosystems was often the last chapter in textbooks and never used as an organizing principle. Most biology textbooks started with a micro level or what we call a model species level and then expanded (Bang, 2007). Further, the majority of the textbooks had almost no hands-on or experiential components. We suggested that this assumed trajectory of learning did not align with Native students' ways of knowing or experiencing the world (Bang, 2007). Thus we were proposing to design learning environments with an ecological orientation and community-based practices as the foundation, to see whether student engagement and learning was better in such environments. Once the project team was formed we also engaged in conversation about the previously mentioned historical perspective on teaching and learning in Indian communities and noted that we hoped that this would be a place for us to reclaim, recover, and refine teaching and learning practices in Indigenous communities.

The early stage of our design process consisted of a series of monthly or bi-monthly meetings to make sense of the goals of the project and to develop a shared vision for it. These meetings soon evolved into specific decisions about a range of issues such as content focus, activities, assessment, and community involvement. The majority of the work in the first year consisted of making sense of issues of science and science education from a socio-historical and larger cultural perspective rooted in a particular place and based on participants' experiences.

Community Design in Action: Social policy and community context. In each of our programs there has been a range of community participation. All of the teachers and research assistants in the project have been local community members. Both communities also had elders and community experts lead activities with children. For example, in

Chicago we had an elder share creation stories and stories focused on plants with children. At our Menominee site we have had community members who work for the forestry department, fisheries and water treatment talk with students. In addition, teachers frequently made connections between the specific tasks children and adults were engaged in with broader issues within the community. Teachers used this as an opportunity to stress needs in the community that invited children to think about science as a career path. For example, while students were learning about issues with the Chicago river specifically, teachers made connections to water issues on different reservations (i.e. the Oneida nation is currently exploring creating a pond for drinking water, the Navajo nation is working to clean up toxins in their aquifers; the Great Lakes Indian Fish & Wildlife Commission was discussed as a community-based scientific organization that was developed to protect our resources and sovereignty). Although these various connections were pointed out some of the time, our efforts were not systematic. We intend to systematically include this throughout the intervention and test its impacts.

Exploring and addressing tensions between western modern science and Native science. The design teams have focused on the ways in which various cultural practices and artifacts, including stories, converge or diverge with ideas in school science, and how to structure activities that facilitate students' exploration of both. Often students are left to navigate and make sense of the multiple cultural contexts in which they live with little support or conversation. Although there has been work on making the practices and expectations of schooling explicit to students, generally this work has been engaged from a deficit perspective, one aimed at ushering students into a different way of doing things (Delpit, 1995). This aspect of our curriculum has begun to emerge by identifying key points within lessons and activities where we think the hypothesized discord is often at an implicit or tacit level or in places where we think there are generative intersections between modern western science and traditional practices and knowledge. We see this aligned with what Gutierrez, Larson, and Kreauter (1995), Gutierrez, Baquedano-Lopez, and Turner (1997), and Gutierrez, Baquedano-Lopez and Tejada (1999) have called the third space or places in which "alternative and competing discourse and positionings transform conflict and difference into rich zones of collaboration and learning." (see also Van Eijck and Roth, 2007).

For example, when our students engage with the concept of biodiversity, community-based views about all things being connected and having a role to play is a resource to be mobilized that easily aligns with the western science concept. However, within many Native communities rocks, water, and other entities that would be classified as "non-living natural kinds" are considered to be different living kinds. We are making these sorts of differences explicit to students and embracing and exploring the reasons for the differences in "classifications," thereby creating a third zone. In this project we are exploring the ways in which the third zone may be supporting the shifts in students' understanding of the nature of science more broadly, in relation to traditions of students' community-based practices, histories and knowledge.

The learning environments**.** A significant focus of our project was the creation of curricular units by the Chicago and Menominee community-based design teams. The curricula were relationally-driven, place-based and problem-based, involving locally meaningful interventions focused on ecosystems. They were organized around the global idea that we (humans, other animals, plants) are all related (See Cajete, 1999, 2000;

Kawagley, 2000, Chinn, 2007). The curricula included a breadth of content concerning plant and aquatic life through a series of hands-on experiences (e.g. cutting down invasive buckthorn from forest), guest speakers (e.g. elders and professionals working in relevant fields), and "labs" (e.g testing pH levels of water samples). At the AIC we used the medicinal garden surrounding the building as an anchor and then branched out to various local neighborhoods to identify and experience urban ecosystems, local forest preserves and lakefront restoration sites. On the Menominee reservation our focus was on the forest and waters but the program included activities like visiting the Menominee water treatment plant which maintains its own laboratory for water quality testing. Another specific element of the curriculum is the inclusion of culturally-based stories that convey some knowledge about nature, primarily stories about plants and animals.

The following is a brief vignette that exemplifies the kind of activities that were designed and implemented. Although there are some particulars to this activity, generally our designers followed a similar structure and logic for all of the activities.

The Chicago program was based on plant ecology and organized around the big idea that everything is related. Each student "recognized their relatives" by engaging in close study with one medicinal plant species that was in the medicinal garden surrounding the AIC. Students "remade a relative" by interacting with the same plant daily in a variety of ways that were integrated into other activities. For example, part of the summer program involved learning about invasive species. One activity was centered around understanding European buckthorn's (an invasive species) impact on local forest ecosystems. We went to a local forest preserve, accompanied by forest preserve staff (practicing scientists) where buckthorn is damaging the health of oak trees (and thus the forest canopy) and ultimately the entire health of the forest ecosystem.

Upon arriving at the forest preserve students were first introduced to the history of the preserve and Native peoples' relationships with the forest before European contact. Through this history students were introduced to their community responsibilties to the forest and to the respectful protocol for entering into special places. They were also asked to locate their plant relative in the forest. After each student located their plant we gathered together to learn about buckthorn from the plant's perspective (including its history in the area) in order to strategically clear (cut) some of the buckthorn. Students learned appropriate community-based protocols for cutting down these plants, safe and proper use of tools, as well as species identification strategies at various stagies in a plant's life cycle.

During this time we were visited by a doe and fawn walking through the preserve. The elder on our trip interpreted this as the doe and her fawn welcoming us and thanking us for the good work we were doing. Students, teachers and other community members then cut buckthorn for a couple of hours. During that time there were a series of mini lessons that took place about other local plants, plant indentification and plant anatomy. We were also fortunate to observe several other animals during the visit including: a possum and possum baby sleeping in the trunk of a tree, a snake, mice, and squirrels.

Design principles of culturally- and community- based science programming. The design principles developed in our work address the issue of discord at multiple levels

including but not limited to: content, orientations to nature, participation and practice. Our own work, and that of others, suggests that culturally-based science curricula has at minimum the following design characteristics: They 1. use local, place-based instruction and hands-on experiences (see Schroeder et al, 2007 for a relevant meta-analysis), 2. are inextricably linked with community participation and practices including community values, needs, language and experiences, (Cajete, 1997), 3. are premised on the idea that nature is not an externality, apart from humans, but rather that humans are a part of nature, 4. are motivated and organized around a big idea, in our case the idea that everything is related and has a role to play in the universe (systems level or ecosystems thinking), 5. place science in an inter-disciplinary or holistic contextualized and invite the learner to view phenomena from multiple perspectives, and 6. explore and address the relationships and tensions between Native science and Western science (e.g. Cajete, 1997), and 7. place science in social policy and community contexts that highlight the need for participation and leadership (e.g. Aikenhead, 2006).

VIII. Community-based design: A closer look.

In the following we focus on a few selected segments from a design team meeting on the Menominee reservation in which elders, teachers, and community members were present. The design team was working on a forest ecology unit and discussing what they wanted the learning goals of the unit to be. In analyzing this section our goal is seeing the larger socio-historical frame that participants are working with and the ways in which this frame functions in shaping the meanings of science and Native peoples' relationship to science. We explore the variations in these meanings and relationships both across individuals as well as across particular individual's utterances. These variations are sites of struggle for meaning, reclamation, transformation and sovereignty. We use discourse analysis to uncover these variations in the context of teacher and designer meetings.

Before turning to the meeting in question, the reader must know something about the history and relationship of the Menominee nation with their forested lands. The Menominee have managed a sustainable logging operation, including a logging mill, for more then a century (Beck, 2002, Davis, 2000, Grignon, et al, 1998). The forest is more than a source of economic values; many Menominee have a deep sense of identity connected to the forest. The forest is a source of game, firewood, medicines, berries and a site for cultural practices. Some Menominee say that if the forest were gone the Menominee would no longer exist as a people. Hunters often express a sense of awe when they note that their ancestors hunted on the very same ground where they are hunting now. We once asked a Menominee hunter what he thinks about when he is hunting and his answer was, "I pray."

The Menominee relationship with the forest has not been free of the history of America and the majority culture domination of Indigenous people. Since the present boundaries of the reservation were established in 1856, the tribe has struggled with outside interests and the federal government. The so-called "Pine Ring" attempted to steal Menominee timber and to gain control of and clear cut the Menominee reservation. Newman (1967) estimates that about one million board feet of timber were stolen from the reservation between 1871 and 1890.

The struggle has been even more protracted and multi-faceted (Grignon, et al, 1998). In 1871 Secretary of the Interior agreed that the Menominee be allowed to cut and

sell logs to mills outside the reservation. Under pressure from the Pine Ring, the government halted the Menominee logging operation in 1878. In 1882 a special act of the US Congress allowed the tribe to cut “dead and down” timber. In 1888 the US Attorney General ordered another halt to logging on grounds that the timber was government property. In 1890 another Congressional act authorized cutting and sale of timber under the supervision of government superintendents. In 1908 a bill authorized the Menominee to build their own mill and to harvest mature trees under a selective cutting system where Forestry Service specialists would mark the trees to be cut. In 1912 agency superintendents began a policy of clear cutting in direct violation of the 1908 act. Selective cutting was reinstituted in 1926. In 1928 the tribe was able to elect an advisory board and the board went to Washington D.C. to protest the mismanagement of the forest and mill. It took until 1951 for the tribe to win an 8.5 million dollar settlement for the failure of governmental officials to carry out provisions of the 1908 act.

At present the logging operation is managed by Menominee Tribal Enterprises. But even now cutting prescriptions are approved by the Bureau of Indian Affairs (BIA).

At one point the Menominee nation was one of the most economically successful Indian communities in North America. Despite federal oversight and mismanagement the Menominee logging operation employed hundreds of Menominee people and generated significant revenues. But in the early 1950’s the federal government began a policy known as termination in which the sovereign status of targeted nations was removed. The Menominee termination act was signed into law in 1954 and implemented in 1961. In effect, it was an attempt to legislate the tribe out of existence. The idea was that all Menominees would become American citizens instead of wards of the federal government. The tribe would receive no more financial support from the federal government, the land would be divided up, and the reservation would become nothing more than another Wisconsin county.

The termination act immediately crippled the Menominee Nation financially, because the tribe had no tax base to generate revenue. The tribal clinic and hospital soon closed. There was deep ripple effect on all aspects of the tribal community. Overnight Menominee County became a pocket of poverty.

The Menominee logging operation had to focus on efficiency rather than maximizing Menominee employment. These operations were managed by Menominee Enterprises, which, despite its name, included non-Indians on the board of directors and they often were in the position of casting the decisive vote. In 1968 Menominee Enterprises used several smaller reservation lakes to create a man-made lake, Legend Lake, and sold shoreline lots to non-Indians. In this case, from the perspective of most Menominees, the economic gains were far outweighed by the loss of sovereignty over the lands and the decision triggered a storm of protest and ultimately led to the restoration movement that achieved success in 1973 when President Nixon signed the Menominee Restoration Act.

The logging operation is currently operated by Menominee Tribal Enterprises (MTE) which is under control of the Menominee Tribal Legislature (though the constitutional relationship between these two independent entities is sometimes in dispute). MTE has won several awards for its sustainable forestry practices, yet its current cutting practices have not always been well-received by the Menominee community. These practices include 40-acre clear cuts and shelterwood cuts which look

quite a bit like clear cuts. Many Menominee people, including loggers, are disturbed by these cuts. They do not see the rationale for abandoning selective harvest, they note that the heavier equipment used for such cuts compacts the soil, they worry about the ecological consequences of these practices and they find them aesthetically displeasing. When community members object to MTE's practices they are often met with the counter-argument that "our practices are based on forestry science."

This is a crude gloss of a troubled yet resilient history and we hope it will be enough to enable the reader to see the shared historical experience that may be functioning in the unfolding of the conversation. There are places in the utterances in which we will clarify terminology using square brackets and italics. We begin with Justin[6], a tribal leader, who has been involved with forest policy issues for over a decade.

> **Justin:** There seems at this sort of moment in time, or in the last decade or two, a great anxiety between science and the way traditionally the forest was managed, and how science is somewhat taking a upper hand at the um, anxiety of a lot of tribal members and loggers and stuff.

Justin begins by locating this issue in a particular moment in time, suggesting that the current problems are different from past problems but are not unrelated. He specifically locates this within the last 20 years or so. He casts science and Menominee traditional practices and knowledge in an oppositional binary and suggests that this binary is causing "a great anxiety." The expression "great anxiety" seems to index a historically-infused emotion and perspective and it has the affect of nominalizing anxiety. Justin goes on to characterize the anxiety by linking it with issues of power and domination and locating it within the lives of community members. Note that there is no balance or integration of science and traditional management but rather science has the "upper hand."

Interestingly Justin names both "tribal members" and "loggers" as feeling this anxiety. Its also important to note that at this point Justin has not located himself specifically within this relationship--- he is narrating it from a relational distance.

> **Sarah:** Are they doing things more scientifically here now, or what, or is that some of the problem between…?

Sarah takes up Justin's construal of "a great anxiety" and science's dominance. She assumes a comparative frame and wants to analyze the difference in more specific detail. She uses the words "more scientifically," pulling out a possible implication of Justin's comment that science is taking the upper hand and implicitly accepting the opposition of science with tradition.

> **Justin:** There aren't many tribal lumber mills *[reference to the Menominee Mill which celebrated its centennial in 2008]* that are a hundred years old. So they don't have a real, the record that we do, and part of the practice, traditions, and oral history that contribute to how they drew up proscriptions *[plans for forest management]*. But, but science is definitely, I think, is creating a lot of anxiety among different tribes <u>because the people who have the knowledge aren't the</u>

people who are making the public policy decisions, and, and for some reason they can't talk, yeah come together or talk, find a way to talk about it where they're understandable and make sense vs. what they know to have had success in the past.

Justin's response to Sarah's question is multi-layered. He wants to complicate Sarah's quantification of scientific practices and appears to read Sarah's comment as suggesting that previous forest management was unscientific. Further, he suggests that the scientists don't have the same record of sustainable forestry that Menominees do, with the implication that Menominees have deeper database of sorts, implying that Menominee knowledge is older and deeper than the scientific knowledge now driving the management of the forest. The exchange also suggests that Justin has multiple frames for thinking about what power is and where it lies within this situation. Justin suggests that Menominee practices and traditions fleshed out or completed a perspective that drove the management of the forest, something that is missing from the current management plans.

There is also a shift from speaking about science as a disembodied entity in his earlier comment to something people do or knowledge that people have. Note also that he backs off from the simple dichotomy of science and tradition to suggest that part of the problem lies with a lack of communication between policy people (e.g. the Tribal Legislature) and people who have the formal knowledge (MTE). Justin notes that the anxiety that is being felt on the Menominee reservation is not something unique. He expands his argument to something that is felt by many tribes and notes that the people in power are not the ones with the appropriate knowledge.

Justin ends his turn by locating the problem in the dialogue between the people involved and their inability to understand one another. Implied in Justin's comment is that this misunderstanding is one based on how scientists are not making sense in comparison to what people know from experience. This last phrase continues the oppositional dichotomy that was originally cast and the comparative frame that Sarah used, but at a different grain size. It has now been located at the conversational level between people. The power dynamic in this comment is multi-voiced because it locates accurate knowledge with the people, but also recognizes that the socio-political context of power does not have the accurate voice driving it.

Importantly Justin continues to narrate this issue from a distance. He has not specifically located himself within the world he is narrating. Sarah in the next utterance notes that Justin has cast this issue on a broader level and wants to bring it back to the Menominee community specifically, she asks "what about here?" Several people speak to this question, talking about issues as broad as intellectual property rights and sharing of information to attitudes conveyed in interactions with decision makers that leave people feeling like they do not understand what is going on.

Daniel, a community member and a long-time logger of the Menominee forest, extends the idea presented by Justin by agreeing that the problem is one of communication. He focuses on the way in which content and naming practices are playing out in the anxiety filled dynamic Justin has identified.

Daniel: They're, they're in charge of the forest (MTE). They manage the forest, and sometimes you get the feeling from them that, 'we're managing it, leave us

alone'. Don't, you know, 'we're doing it.' And they're doing...science and technology, different things, [unknown], and they call it all different names. Now, in the past 10 years when this has all been really comin' to a head, they're callin' it all different names, and most people don't understand what's goin' on.

Daniel pushes further on Justin's point that there is a problem of communication. He appears to be struggling with how the larger frame that science is power is playing out in the day to day and moves to discuss this on a more detailed level. At this point in the conversation the original oppositional binary and the socio-historical lens that have been dominating the conversation seem to fade into the background. The conversation takes on a different focus, one related to day-to-day forestry practices. Specifically they focus on the different cuts and the rationales for cuts. Daniel places himself within the situation, and then projects the voice of those in power. He also locates the developing tension within a similar time frame as Justin, but goes on to suggest that there is a deliberate obscuring in the naming practices by the people in charge of forest management (MTE) over the past decade and that the naming practices function as a form of domination. Daniel is also critically reading the practice of scientists and the management of the forest but from a different point of view.

Sarah: 'Cause they don't let us know.

Sarah apparently sees herself in Daniel's comment "most people don't understand what's goin'on." She voices anger about the situation, placing her emotionally in the conversation in a different way than either Daniel or Justin have. In this comment, Sarah speaks from a position of lack of agency.

Daniel: Yeah. You know, there's, like we talked before there's seed tree [cuts] and there's shelterwood [cuts]. They're basically the same thing. But, they're for different trees. It can look like the same cut. But they'll tell you that it's, 'you know we didn't do a shelterwood, that's a seed tree." And, there's regeneration cuts and then there's, uh, conversion cuts, for clear cuts. There's a whole bunch of different words that they can use, and, the average person looks at it, and doesn't understand it.

Daniel reiterates his point about scientific language as a tool for domination and expands on his earlier comment, by noting how content and naming are intersecting and contributing to the misunderstanding between people. Danial articulates specific kinds of practices that vary with particular kinds of trees in the forest as well as the different terminology used for them. Each of the cuts serves a different function, depending upon the tree biology, the age of the particular section of forest, and the overall management plan for the forest. There are a few questions that follow about what exactly the difference is between a seed tree cut and shelter wood cut and the differences in cuts that some of the community members who are present don't understand (even those who have been loggers). This turn in the conversation reinstates a socio-historic frame and Justin returns the conversation to the socio-political level and to Menominee people's general relationship with "science."

> **Justin:** I think one of the problems with our anxiety about this is that we don't have a [unknown]] or we don't own the science or contribute to the decision making process. So as a result, we're, we're allowing our resources to be managed and dictated by, um, science and professionals and I think probably every one of our proscriptions are drafted by a non-Menominee at this point and, and, and that, we in the past we, we had a sense of ownership and knowledge that contributed to that decision making and we don't now.

There is a shift in Justin's stance here. Importantly he now places himself within the situation and gives voice to the anxiety as "ours" in an inclusive sense and "we" in terms of owning the science. Justin suggests here that we, the Menominee people, don't own or contribute to "science" or the associated decision making processes. Justin also seems to be struggling with another perspective in this utterance, one that does not take on the accepted role of subordination in Sarah's comment. Justin suggests that we (Menominees) are allowing the situation to happen. Although the phrasing has a negative connotation, we read this as Justin's belief in a transformative potential that is within the control of the community. We could read, "we are allowing" as a deep belief in self-determination and sovereignty. He notes that the collective community once had a sense of ownership and knowledge that was valuable and contributed to the decision making but that it is not present now. This shift in Justin's stance shifts the power frame that was previously in place. Now the power and choices, and potentially the criticism, are attributed to community, not to science. Daniel, picking up Justin's reference to the proscriptions being drafted, identifies his own relationship to the situation and seems to push on Justin's collective we.

> **Daniel:** A big problem with the proscriptions up here, I mean from workin' in the woods, bein' closely related or associated with people who still work in the woods, is, you know they feel so much that it's, the forest is being experimented on. This place is being experimented on, and, you know, they do a lot of good things, and uh, I got problems with some of the things I seen that, you know, that did work, that they were doin', it was right scientifically, but culturally, it just looks so bad. I mean the buffer zone [an effort to insure that there are stands of trees between roads and clear cuts so that they are not so visible], is the best thing they did, and that's the best thing you guys did in stoppin' them from going up [to the road]…And the, the areas that are, you know. The people have a say. They don't think so but they do have a say.

Daniel's response is again multi-voiced. He pushes Justin's analysis to a finer level of critique and returns to a content and practice level analysis of the forest management program. He begins to locate himself and his family as people who have been deeply connected to the woods for a long time. He narrates his identity in relation to the argument he is making at a more specific level of detail than previously.

He states that the people who are deeply involved in the forest feel that the forest is being experimented on. Daniel appears tp defend some of the decisions that the scientists are making, pushing on the distinct oppositional binary cast that has been

operating in the conversation up to this point. He says that some of the things people were doing are correct by scientific standards, but he tempers that with cultural standards. Here Daniel is struggling with the scientific rationale for the clear cut, that he seems to approve of, but he also knows that the appearance of a clear cut sits in deep opposition to cultural values. He refers to the buffer zone, a policy decision to visually keep the clear cut away from community view by leaving a section of the forest intact between the clear cut and easy viewing access.

Daniel also is struggling with Justin's all encompassing comment that the community no longer feels a sense of ownership nor contributes to the decision making. He says that the buffer zone decision was a good thing that the people contributed to. Daniel continues to push on a collective stance that Justin puts forth when he uses the phrase, "the best thing you guys did," placing himself outside of the group that contributed. (He doesn't say the best thing *we* did). It seems in this exchange Justin and Daniel are wrestling with their more specific identities and roles within the community context (Justin has not been a logger nor worked for MTE but Daniel has). It is unclear whether these are tensions with each other or merely a question of different perspectives. Daniel's return to a larger collective framing suggests that this specific identification is secondary. Daniel appears to reify the transformative potential Justin implied at the end of his comment because he also places the power within the community's hands. This agreement that the people have a voice moves the conversation to articulating a goal for the forest unit.

> **Justin:** And instilling that in our kids is I think is one of probably the most important attributes of this unit.

The conception of the unit becomes one about having children understand that larger socio-historical context and their role within this context in relation to science. Young people should have a sense of sovereignty and voice, in Justin's view. Note, however, that increasing language or knowledge of the scientific process of scientific way of knowing has not been articulated yet.

> **Daniel:** Yeah, and lettin' them know everything, you know, that they have, they're the ones who can be in charge.

Daniel agrees with Justin's comment but again wants to extend it. "lettin' them know everything that they have" could be read as a reference to the knowledge and history they have. Daniel further notes that the current positions are not static, but rather that Menominees "can be in charge" of the forest.

The subtle differences in these two turns have potentially dramatic impacts on the design decisions that could be made and the priorities for learning. Justin's stance could lead to a unit that privileges understanding of history and meanings of sovereignty from a broad frame. Daniel's stance could lead to a unit that engages students in learning the scientific language and being able to challenge practices at the day-to-day level. Of course, one could argue that both points of view enhance and deepen approaches to learning.

In a separate but related meeting the next day Justin becomes more explicit about relationships between science and tradition. He says "We have to take control of science so that our values are reflected in forestry practices." This statement both recognizes the binary opposition and dissolves it. He goes on to say "and we have to teach our children that they need to take ownership of science so that they can control what happens to our forest."

Although this fragment of community discourse shows a progression from a third person to a first person perspective and a shift from viewing science and tradition as a dichotomy to forms of knowledge that can be integrated, the story is not so simple. Thinking in terms of dichotomies such as school and home, or science and tradition reflects well engrained habits. These themes have been constantly revisited, challenged and reconstructed throughout our program.

Note also the interweaving of community concerns with the creation of curricula as ownership of science becomes a central theme. From this perspective, community values should and do become an integral part of science instruction. In our program implementations we noted several times when community members told children that learning about the forest was part of their responsibility as Menominees. Community planning meetings also allow community members to work through their own difficult experiences with formal schooling and to take ownership of science instruction. At a community planning meeting about a year later, Daniel made the following side comment to a teacher; "You know when we first started meeting, I came because I care about our kids, but I didn't see how I could do anything useful. Now I can see how I can help you in lots of ways."

IX. Partnership in community: Some consequences

The foundation of CBD rests on the comprehensive participation of community members, including teachers, elders, parents, community experts, researchers, and youth in all aspects of the research, including conceptions of the problems, project design and implementation, data collection, analysis, and dissemination. The project uses the design process for learning environments as opportunities for professional learning both for the teachers and designers of the project.

Some results. There is reason to think that our project has been successful. First, there is evidence that children's conceptions of science have changed as a result of their participation in our programs. Most notably we have witnessed a shift from the belief that one only learns science at school to the statement that one can learn science from parents and elders and by exploration. There is also a shift from seeing science as a body of knowledge in the direction of seeing science as a set of practices for learning about the world. We report the details of these results elsewhere (Bang and Medin, in press). Finally, performance in science on standardized tests has improved substantially since our program began. Although we cannot isolate our efforts as instrumental to this improvement, we are nonetheless encouraged by this development.

Perhaps our most surprising results are the shifts in goals for the people working on our project. Our research and design teams have consisted of about fifteen community members at each site, eight part-time research assistants, five junior research assistants (at the AIC), eight teachers, two full-time research assistants and curriculum specialists, one postdoctoral fellow, three graduate students and four PIs. Elders and other community

members have also been willing and able to participate in the design. Of this group all but two are Native-American.

Community-based design has had a clear impact on the adults working on the project. Two graduate students have completed their dissertations. This contribution to the infra-structure of science was anticipated but the following seven were not: 1. Two members of the Chicago design team have been admitted to the Northwestern School of Education and Social Policy PhD program. 2. One of the full-time research assistants has enrolled in a master's program. 3. An research assistant who dropped out of school and later earned her GED began undergraduate study in the Fall of 2007. 4. Another part-time research assistant working towards an Associates degree transferred to a university with the aim of going on to graduate school. 5. One of our Menominee research assistants started college, and another, ten years after completing her associates of arts degree, returned to college to obtain a teaching degree. A third has recently also returned to college after an extended time away from it and plans to pursue graduate study in biological sciences 6. Two other RAs in the Chicago community have indicated an interest in applying to graduate school after they finish their bachelor's degrees. Virtually all of these community members say that working on the project was a key factor in their decision-making. These dramatic changes indicate a deep motivation to take ownership of schools and to assert tribal sovereignty.

X. Discussion

Our previous work examined the hypothesis that there is discord between Native-American cultural ways of knowing biology and the cultural ways of knowing in school science and that this discord is at the heart of student disengagement and underachievement. In part we have learned that a central feature of the discord students experience is the lack of connections across the multiple contexts in which students learn science. This lack of coordination manifests itself across a range of levels, including, but not limited to: content knowledge, practices, values, and relevance to family, community, and society at large. We continue to work with and refine our understandings of what this discord means and what it looks like in teaching and learning practices, and how addressing it pedagogically opens new opportunities to develop effective teaching and learning strategies that build on the variety of resources for learning Native children bring to the classroom.

This chapter describes our initial effort to explore the process that enabled design teams to construct these types of learning environments. These learning environments have evolved to a place where there is a deep integration of traditional Native knowledge and history and western modern scientific knowledge and processes, focused on contemporary problems and issues. A general problem that the project and design teams are only beginning to address is the analysis of classroom level events, the moment to moment interactions and unfolding of teaching and learning. We see this challenge as historically rooted and amenable to the framework that the unique structure of our design teams provide.

Developing culturally-based science curricula is far from straightforward. One of the key aspects of this work has been the evolution of our understanding of what culturally-based science programming means and the ways in which to design and study the programs. “Culture” and “Science” are two concepts that are strongly subject to

stereotyping and simplistic definitions. For example, it may be easy for some people to think of science as a body of knowledge and to imagine scientists as (white) men wearing white lab coats and using beakers and test tubes. Similarly it is easy to think of culture as a set of ideas about *what* people think or customs rather than as affecting *how* people think. If these stereotypes and reductionist approaches remain unchallenged, then it is natural to take some pre-existing science curriculum and build in a cultural connection by "adding culture to it." Indeed this is an approach that has been widely advocated and used (Yazzie-Mintz, 2007; Hermes, 1999) but has failed to have the impacts hoped for, perhaps because it has not addressed the core problems of culture in science.

We think that cultural practices and their connections with Native ways of knowing must be the foundation of a community-based science curriculum. There is a strong body of Indigenous scholarship exploring the philosophies and methods of Indigenous ways of knowing (or "Native Science") the natural world and the relationships and tensions with western modern science (i.e. Cajete, 1997; Deloria, 1979; Deloria & Wildcat, 2001; Kawagley, 1995). A key aspect of developing our framework has been to resist placing western modern science and Native science in an oppositional dichotomy because it has the effect of falsely simplifying both ideas of western modern science and Native science (Cajete, 1997; Maryboy et. al., 2006).

Culture. One of the most salient shifts in our community design teams concerns the ways in which culture is being conceptualized. Initially, many community members tended to think of culture as something of an "add-on," to be put into our lesson plans after the science part was worked out. This might take the form of "historical connections." Now almost all community members see culture as foundational where science is built around that base. One of our teachers vividly illustrated this point with a picture she drew representing her conception of science education. She drew a large turtle (she is a member of the turtle clan) and added microscopes, test tubes and the like on its back.

This shift is also evident in other socio-cultural approaches to education. An increasingly influential framework that includes the study of within group variation, for example, (Nasir, et al, 2005; Gutierrez and Rogoff, 2003, Moll and Gonzalez, 2004) proposes that, although the construct of culture is problematic, people nonetheless "live culturally." From this perspective a key object of study is the wide-repertoire of sense-making practices that people participate in, particularly in everyday contexts**.** Lee (1993, 1995, 2001) has used this approach for the design of learning environments that leverage knowledge associated with everyday experiences to support subject matter learning (in her case literacy practices). From this framework, cultural practices can also be seen as providing alternative "perspectives" on epistemologies. This understanding of culture implies that there is no cultureless or "neutral" perspective any more than a photograph or painting could be without perspective. In this sense, everything is cultured (Rogoff, 2003), including the ways schools are organized and education is implemented (Warren, et al, 2001, Lipka, 1998), layout of museums (Bitgood, 1993; Duensing, 2006), scientific practices and the practices associated with teaching science in school (Warren and Rosebery, 2004). Sometimes these perspectives are explicit but they are often implicit in practices and symbols.

This framework is highly relevant to both formal and informal science learning contexts. 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 (Wolpert and Richards, 1997, Ochs, Gonzalez, & Jacoby, 1996). 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 & Hudicourt-Barnes, 2006). These and other findings undermine the view that professional scientific practices are largely abstract logical derivations disassociated with the forms of experience and practice in the everyday world (Warren et al. 2001). This observation also underlines the opportunity of educators working in and with designed environments (Hudicourt-Barnes; 2004, Cobb, et al, 2003; Bell, in press) to take better advantage of the (cultural) practices that a diverse set of learners bring to the environment.

A Second Look at Partnerships and Innovations**.** We believe that our partnerships can serve as a model for other partnerships among research universities and both tribal institutions and other institutions that traditionally have served under-represented groups. But we also should caution that it is "easier said than done." The four of us didn't just run into each other at a coffee shop or a conference and decide to collaborate and, to the extent we have been successful, we must acknowledge coincidence, challenges and convictions. Medin was able to start work on the Menominee reservation only because an early contact at the College of the Menominee Nation encouraged him to visit elders, instructed him in the proper protocol, and gave him some important introductions. Bang was not only involved with the American Indian Center of Chicago but also a graduate student in the Learning Sciences at Northwestern University where she meet Medin. Bang also had contacts on the Menominee reservation through friendships, AIC programming and the fact that NAES had both Chicago and Menominee campuses. Washinawatok was Dean at the Menominee campus of NAES and our first partnership involved the two NAES campuses and Northwestern. Chapman's Uncle, who was on the Board of Directors of NAES, became involved in our project, and saw the potential synergy that Chapman would bring to the project. So connections are important and chance connections are to be appreciated.

This project has not been without its challenges. Washinawatok provided strong initial leadership on our project but had to step into the background temporarily when she became Tribal Chair. NAES ran into a financial crisis and the two campuses went their separate ways---the Menominee campus was ready to close, but then was rescued at the last moment to become a campus of East-West University based in Chicago. East-West University is not a tribal entity and this long distance relationship has not always been smooth. In Chicago our project focus shifted from NAES, Chicago, to the American Indian Center. And none of the institutions mentioned in this paragraph had a previous indirect cost agreement with the federal government or was very experienced with managing federal grants. So there have been challenges.

But convictions thrive and grow on challenges. Throughout the institutional upheavals there has been a strong group of elders and other community members that have offered perspective, prayers, and passion for our project. Northwestern University has also provided technical advice and training in grant management. (One member of Northwestern's grants and contracts office took us aside and revealed to us that he is an

enrolled Lakota and that he would do what he could to help us). In addition there has been a drove of young people getting involved. At the American Indian Center we have created a cohort of under-graduate and graduate students (reaching 16 at its peak) that are connected to community but come from several different institutions of higher education. This has changed their college experience and the dynamic that Indian students need to leave community to attend and succeed in institutions of higher education or attend tribal colleges. These college students now have the expectation that rigorous research can be done directly in community and they know that they can navigate between multiple contexts. Our project begins to hint at new configurations of training for Native scholars.

XI. Conclusions

Although this chapter appears to be at a different grain size and perspective than the focus of typical innovations in learning science research, we think it is useful to represent this side of innovative work. If learning sciences research is to have significant impact in the world on the learning and achievement of students from non-dominant backgrounds, researchers must begin to recognize the real world dynamics of community-based research. Often research projects are organized and planned around university-based models and expectations that may not be sensitive to socio-historic community contexts and relationships with science and science education. Hindsight reveals that we have made many false steps, but also that we seem to be moving in the right direction. Our project has not only had positive results in the areas of our initial focus but also it has had ripple affects that we did not foresee.

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[6] Here and elsewhere we use pseudonyms.