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Developing a Sense of Place and an Environmental Ethic: A Transformative Role for Hawaiian/Indigenous Science in Teacher Education?

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Abstract

This exploratory study reports findings from a professional development workshop on curricular trends in Hawaii. Nineteen secondary mathematics and science teachers from Japan, Malaysia, Indonesia, Thailand, Korea, Philippines, U.S. and People's Republic of China were asked to write about the role of indigenous science in science. Responses showed most ethnic Asians from Asia nations viewed indigenous practices negatively. After reflective written and oral exercises to develop a personal sense of place and a presentation on indigenous Hawaiian practices related to place and sustainability, most evaluated indigenous practices more positively. Teachers discussed environmental issues affecting their communities and critiqued the absence of locally relevant science and ecological knowledge of indigenous peoples in their national science curriculum. Teachers identified local issues of air and water quality due to industrialization, fires, deforestation, and resource exploitation. These findings suggest professional development that includes indigenous, sustainable practices and personal, place-based activities provides a conceptual framework for transforming mainstream science curricula into meaningful, problem-based curricula relevant to environmental literacy.

Introduction

Contemporary mainstream science education shares similarities with global marketing campaigns inducing individuals to consume the same products and aspire to similar lifestyles regardless of local cultural and environmental contexts. Western modern science (WMS)

curricula oriented to preparing students for an increasingly technological, urbanized global economy provides a universalistic view of science that separates learners from their experiences with local environments and their host culture's traditional ecological knowledge (Snively & Corsiglia, 2001; Kawagley, 1999). For learners, science studies provide a range of opportunities for inquiry and place- based learning involving the analytical, science based knowledge that is fundamental to environmental literacy. Instead in many schools, science learning is driven by needs for students to perform well on standardized science tests and international tests such as TIMMS, Trends in International Mathematics and Science Study, that lead to increasingly uniform curricula as nations, including the United States, compete on student performance (http://timss.bc.edu/timss2003.html).

Students in Hawaii's schools have a unique natural laboratory to explore fundamental biological questions involving evolution, adaptation and interactions of humans and the environment on isolated island systems. But Hawaii's students historically study mainstream, textbook-based science. They may become literate in school science but seldom learn about issues of endangered and invasive species or soil and water pollution in their own communities. At the secondary level, science classes that address locally relevant marine science and natural history tend to be targeted towards lower academic track students, while college bound students enroll in mainstream biology, chemistry, and physics courses recognized and required by many colleges.

Middle class students who are likely to pursue postsecondary schooling are served reasonably well in Hawaii's mainstream schools. They take college preparatory classes and enter universities where their science and science education professors achieve professional status through research and writings assessed by peers who belong to nationally and internationally recognized knowledge-based professional subcultures. It is ironic that specialists studying Hawaii's flora, fauna, terrestrial and marine ecosystems, archeology, and geology may be located in research institutions anywhere in the world.

In college, Hawaii's future teachers, especially those in elementary programs, are unlikely to gain the science knowledge and tools to integrate their familiar environments into their curricula. Even nationally accredited elementary teacher education programs require only two semesters of introductory biological and physical science. A few years ago, one of my science methods students said teachers at her public school on Kauai had decided on bears as the

theme of second grade science. Even when teachers are knowledgeable about Hawaii-oriented science, school administrators' desires to raise standardized test scores by adopting mainstream curricula tends to impede the teaching of standards-based, locally relevant science.

This is unfortunate as public school teachers in Hawaii primarily work with students whose worlds are largely limited to their immediate families and neighborhoods, and communities. Teacher education programs and science teaching standards stress the importance addressing student diversity through student-centered lessons, but once in the schools, teachers find that the emphasis on preparing students to perform well on standardized tests of reading and mathematics contradicts National Science Education Standards (National Research Council, 1996) directing teachers to:

> Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students. In determining the specific science content and activities that make up a curriculum, teachers consider the students who will be learning the science (p. 4).

An elementary teacher with the academic preparation to teach Hawaii relevant, standards-based science lessons critiqued the mainstream language arts, mathematics, and science curricular programs her school purchased:

> With the curricula that we have to cover there is little time for science and the content seems so "mainland." Discussing woods such as oak or redwood is okay, but yet kind of silly because who has seen an oak or redwood tree, much less one in Hawaii? We have our own woods here, but if you follow the _____ science content, you do not get to cover that…There are a lot of great ideas from *Malama*…but I am afraid to do too much of it for fear that I would be accused of not following the curriculum (which they paid a lot of $$ for).

These comments reveal teacher disempowerment and a critique of school policies that put scarce financial and teaching resources into curricula unrelated to students' lives and experiences. An outcome of focusing on improving reading and mathematics test scores to meet the No Child Left Behind Act is a reduction of scientific and environmental literacy. Environmental literacy, the ability to understand, monitor, and maintain or restore the integrity of environmental systems all life relies on is marginalized in hopes of producing what Sternberg (2003) calls pseudo-experts:

> Conventional methods of teaching may, at best, create pseudo-experts—students whose expertise, to the extent they have it, does not mirror the expertise needed for real-world thinking inside or outside of the academic disciplines schools normally teach (p. 5).

Sternberg's research shows that teaching and assessment that include analytical, creative, and practical thinking enables students from more diverse racial, ethnic, educational and socioeconomic backgrounds to be successful learners whereas the analytical approaches of mainstream schools reduces diversity. He thinks teaching "must relate to real practical needs of students" and that practical, creative, and analytical teaching leads to the "successful intelligence" needed in fields such as teaching and science (*ibid*, p.5). Sternberg notes that reducing democratic outcomes and producing pseudo-experts incapable of real-world problem solving has serious societal implications. His current work examines the role of successful thinking in wisdom defined as "the use of successful intelligence and experience toward the attainment of a common good" (*ibid*, p.7). He worries that test-driven schools will not educate citizens and leaders with the real world experience needed to make wise decisions in an increasingly complex, interrelated world.

A World of Difference

The history of western science as a cultural enterprise suggests that knowledge-building and technological innovation are driven by the interests of dominant elites (Gould, 1993; Takaki, 1993). Science as an objective quest for knowledge developed in the context of European imperialism and the quest for new lands and resources. Western science methods of knowledge building that involve measuring, classifying, collecting, dissecting, and mapping of everything in a material world are antithetical to a Hawaiian world view that understands humans and nature in a familial relationship.

Hass (1992) writes that Hawaii's schools began as a vehicle for monoculturism, "the practice of catering to the dominant or mainstream culture, providing second-class treatment or no special consideration at all to persons of non- mainstream cultures" (p. 161). Culture may be defined as "a system of values, beliefs, notions about acceptable and unacceptable behavior, and other socially constructed ideas characteristic of a society of a subgroup within a society" (p.377, Garcia, 1999). Cultural differences provide a way for dominant groups to portray others as

outsiders of lesser importance. Negative stereotypes may lead educators to devalue and exclude the cultural knowledge, perspectives and practices of marginalized groups and hold lower expectations for these students. A review of the history of education in Hawaii shows that Hawaiian language and culture were largely excluded from mainstream schools after Hawaii became a territory of the United States in 1898. Cultural and economic marginalization contribute to statistics showing that Native Hawaiians in public schools, at 26% the single largest ethnic group, experience the lowest school success of any group (Kanaiaupuni & Ishibashi, 2003).

But Hawaiian cultural practices and perspectives have much to contribute to environmental literacy and an ecosystems understanding of human interactions with the natural world. Until a monetary economy and policies allowing private ownership of land developed in the 19th century, most Hawaiians lived and married within *ahupua'a,* a land division extending from mountaintop to the edge of the reef containing freshwater and the resources necessary to sustain the population. Those living upland, *mauka*, exchanged products with those living *makai*, towards the sea (Abbott, 1992). Dependence on the resources of the *ahupua'a* produced long term, detailed environmental knowledge revealed in place names of winds, rains, springs, and other environmental features (Pukui, *et al*, 1974).

Traditional Hawaiians view humans as part of a world in which plants, animals, and natural features are alive with ancestral and spiritual significance. Close observation and a worldview based on interdependence support an ecosystems understanding of the world. Many land animals and plants had counterparts in the sea, such as the pairing of pig, *pua'a*, and triggerfish, *humuhumunukunukuapua'a (Rhinecanthus rectangulus*) or Polynesian rat, '*iole* (*Rattus exulans*) and the seaweed, *waiwai ' iole* (*Codium edulis*). Hawaiians developed a binary naming system similar to the Linnean nomenclature system, as seen below in *naupaka kahakai*, *Scaevola sericea*, the indigenous coastal species adapted for heat, dryness, and seawater dispersal and *'ohe naupaka, Scaevola glabra,* an endemic upland species adapted for higher rainfall and bird dispersal of fleshy fruit (http://www.botany.hawaii.edu/faculty/carr/scaevola.htm).

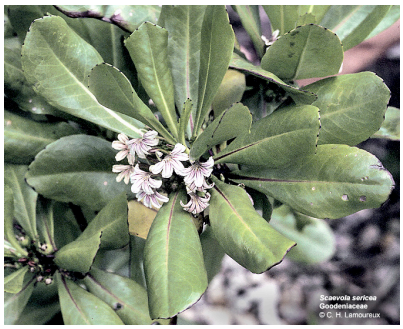

Figure 1. *Naupaka kahakai*, *Scaevola sericea*, indigenous to Hawaii (left), *'ohe naupaka, Scaevola glabra,* endemic to Hawaii (right).

The Hawaiian proverb, *He ali'i ka 'aina; he kaua ke kanaka* translated as "The land is a chief, man is its servant" indicates Hawaiians recognized that active care (*malama 'aina*) and respect/love (*aloha'aina*) for all that sustained them enabled their survival (p. 62, Pukui, 1983). The impact of humans on the natural world and human reliance on intact ecosystems has only recently begun to be appreciated in technologically advanced nations as limits to resources and global impacts of human activities become evident. Reinforcing their economic value to society, the energy capturing, nutrient cycling, and environmental cleansing processes of natural ecosystems are framed in economic terms as *ecosystem services* (Daily, 2003).

A place-based, environmental literacy focus in science teacher education and curriculum development takes on urgency in the light of evidence that human activities have become the most important evolutionary force in the world (Palumbi, 2001). Emerging as an interdisciplinary theoretical field in education (Gruenewald, 2003; Perez, Fain, & Slater, 2004), learning associated with place produces the ecosystems knowledge integrating humans and nature that characterizes sustainable cultures (Orr, 1992; Cajete, 1999, 2000; Kawagley, 2001). Disinger and Roth (2003) stress the active problem-finding, problem-solving, place-based nature of environmental literacy: "Environmental literacy is essentially the capacity to perceive and interpret the relative health of environmental systems and take appropriate action to maintain, restore, or improve the health of those systems."

When Hawaii revised its science content standards in 1999, a Hawaiian saying *Malama I Ka 'Aina, Sustainability,* to care for the land that sustains us was included as a standard. With 300+ plant and animal species, the highest number of candidates for protective status; about a fourth of those already protected under the Endangered Species Act, 107 of 286 (Song, 2005);

and a 90% of endemic species found nowhere else in the world, environmental literacy is an immediate issue for everyone in Hawaii.

> Kanahele's (1986) writing speaks to Native Hawaiians and residents of Hawaii today: If we are to be truly consistent with traditional Hawaiian thought, no one really owned the land in the past…The relationship was the other way around: a person belonged to the land…We are but stewards of the *'aina* and *kai,* trusted to take care of these islands on behalf of the gods, our ancestors, ourselves, and out children (pp. 208, 209).

Culture and Perception of the Natural World

Sociocultural theory assumes that learning cannot be dissociated from interpersonal interactions located in cultural frameworks (Lave & Wenger, 1991; Cole, 1996; Gee et al., 1996). Socially situated learning recognizes that values, emotions, experiences and cultural contexts are integrally related to learning. The recognition that different cultures have different ways of understanding how people relate to each other and the world is the foundation for explicitly addressing cultural contexts in teacher education programs. If not brought to awareness mainstream teachers may only become familiar with superficial, even contrived cultural elements such as the addition of pineapple to make a Hawaiian pizza.

Cross cultural research by Nisbett and his Asian colleagues (2003) yields insights into the role of culture in shaping views of nature. Comparisons of Asian and American perceptions suggest that Asians are more likely to see humans and their surroundings as part of a complex system while Americans tend to see individual actors. Nisbett suggests that *feng shui,* the study of how a structure relates to its environment, reveals Asians perceive the world as composed of complex relationships while the American tendency to problem-solve with series of steps indicates rule based, atomistic, universally applicable thinking. His results indicate that "Westerners are more analytic, paying attention primarily to the object and the categories to which it belongs and using rules, including formal logic, to explain and predict its behavior." Nisbett warns educators that "it might be a mistake to assume that it's an easy matter to teach one culture's tools to individuals in another without total immersion in that culture" (http://www.umich.edu/news/Releases/2003/Feb03/r022703a.html).

Cultural differences ranging from superficial to ideological provide a context for examining school success of students from different cultural groups. In Hawaii, for example, a host culture emphasis on relational identity grounded in family and place differs from the

dominant American emphasis on personal identity. In mainstream classrooms, students learn science in a culture of individualistic, competitive practices leading to individual rankings. Hawaiian worldviews establishing humans in familial, caring relationships with the natural world are antithetical to mainstream ideologies grounded in scientific progress, individualism, and capitalism. Influenced by Descartes (Orr, 1992) and Isaac Newton's shaping of scientific communication (Bazerman, 1988) mainstream WMS and its product, school science, tend to portray science as the discovery of universal truths based on data gained through objective, reproducible experiments stripped of emotion, cultural contexts and values.

One outcome of being socialized in WMS is a tendency for science teachers to be less aware of issues of culture in education (Greenfield, 2005). But some scientists are beginning to recognize the importance of grounding science, especially environmental science, in experiences and emotions leading to an environmental ethic seen in Hawaiian values of *malama 'aina,* active care for the land and *aloha 'aina*, love for the land. David Orr (1992), an environmental scientist criticizes WMS for separating people from the natural world:

> Cartesian philosophy was full of potential ecological mischief, a potential that Descartes' heirs developed to its fullest. His philosophy separated humans from the natural world, stripped nature of its intrinsic value, and segregated mind from body. Descartes was at heart an engineer, and his legacy to the environment of our time is the cold passion to remake the world as if we were merely remodeling a machine. Feelings and intuition have been tossed out along with…love. A growing number of scientists now believe, with Stephen Jay Gould, that "we cannot win this battle to save [objectively measurable] species and environments without forging an [entirely subjective] emotional bond between ourselves and nature as well—for we will not fight to save what we do not love" ("Enchanted Evening," *Natural History*, Sept. 1991).

Transformative Learning and Curricular Restructuring

If mainstream school science is viewed as immersion in the culture of western science, perhaps immersing mainstream teachers in their students' indigenous or sustainability-oriented cultures and communities holds the potential to help them teach a more complex, systems oriented science that supports environmental literacy and recognizes the role of culture in learning. Over the past 4 years, support from awards under the Native Hawaiian Education Act has enabled approximately 100 K-12 Hawaii teachers to enroll in EDCS 433 Interdisciplinary

Science Curricula, *Malama I Ka 'Aina, Sustainability*, a class which includes a multiple day culture-science immersion co-instructed by Native Hawaiians, science educators, and scientists (Chinn & Sylva, 2000, 2002). Through this class, teachers develop and teach culturally relevant, place and standards-based curricula (see http://malama.hawaii.edu).

Place-based culture-science immersion supports teachers in developing personal and professional connections to their *ahupua'a*, the bioregion that landscape architect Thayer (2003) terms a *lifeplace* and defines as the region sustaining the unique human-natural community in which one lives and works. As teachers' environmental literacy develops, they learn how to use their immediate environments for interdisciplinary, experiential lessons that lead to an ethic of care and personal responsibility, *kuleana,* as indicated in the state science standard *Malama I Ka 'Aina, Sustainability*.

Establishing a personal connection and acquiring the tools to study one's lifeplace can lead to transformative teaching and learning in science. Hall (2004) defines transformative learning as "the process of learning, whether in formal or informal educational settings which is linked to changing the root causes of environmental destruction or damage" (pp. 170-171). Transformative learning relevant to environmental literacy creates "pedagogical spaces for adults to learn to transform their lives and the structures around them" (*ibid*, p.190). This is in line with Science Teaching Standards urging teachers to translate science goals "into a curriculum of specific topics, units, and sequenced activities that helps students make sense of their world and understand the fundamental ideas of science (p. 4, NRC, 1996)" and has much in common with Disinger and Roth's (2003) definition of an action oriented environmental literacy. It can be seen from Hall's list of elements of transformative environmental education below that environmental education leading to environmental literacy has as much to do with culture and society as science:

- developing a sense of place;
- recognizing the importance of biodiversity;
- connecting with nature;
- revitalizing traditional and indigenous knowledge, values, and practices;
- building social networks;
- understanding power-knowledge relationships; and
- learning from elders.

Teachers who value and incorporate indigenous knowledge and voices into their teaching broaden the knowledge base for thinking and acting critically in the world and provide a conceptual bridge, though one not always easily negotiable due to ideological and ontological differences, between indigenous and mainstream cultural systems. Research collaborations involving indigenous and non-indigenous individuals with expertise in tradition knowledge and western science provide models of the synergies to be gained when traditional and western science knowledge bases are combined to understand particular environmental issues (Poepoe, *et al*, 2003). Until Hawaiian became a written language, carefully conserved knowledge was transmitted through apprenticeship and participation in cultural practices. Hawaiians were absolutely dependent on the wisdom of old people as "the equivalent of libraries" (Diamond, 2001). This transmission was broken with the institution of compulsory schooling in an English only environment after Hawaii became a territory. Understanding the role of language, place and contextualized, interpersonal experiences in cultural transmission provides insight into indigenous peoples' determination to shape education from their own cultural perspectives (Cajete, 1986; Kawagley, 1999; Smith, L. 1999; Smith, G. 2003). Authentic, personalized environments and authentic, experience-based learning are still critical factors for success in the schooling of native Hawaiian students (Kawakami and Aton, 2000).

Connecting Informal Learning to School Science

I learned to love science because my father, a science teacher, exposed his children to informal science through outdoor activities that led to interest-driven study of Hawaii's natural history. Virtually none of my learning and experiences translated into school science, but I never questioned it. As a secondary science teacher, it took me years to recognize the irony in Native Hawaiian students being least successful of all Hawaii's ethnic groups in school science though coming from a culture sustained through broad-based environmental literacy. Years later I interviewed a Native Hawaiian female engineering student who reported that her friends' academic paths were shaped by elementary teachers who grouped them by perceived academic ability and behavior, setting the stage for academic peer groups that persisted through high school and beyond (Chinn, 1999b). Research with my culturally diverse preservice teachers (Chinn, 2003) revealed that their views of teaching are shaped by life experiences interpreted through the lenses of culture and schooling. These findings support socio-cultural theories of learning that are the rationale for Hawaii Teacher Standards

(www.htsb.org/standards/index.html) and Science Teaching Standards (NRC, 1996) that stress connecting students' informal learning to school learning.

Isabella Abbott, the first Native Hawaiian woman to earn a doctorate in science became interested in botany not through science classes but through her mother's knowledge of plants and her principal's support of her interests (Chinn, 1999a). She listened as her mother, born and brought up on Maui discussed local differences in knowledge and practices with cultural expert Mary Pukui from the Ka'u district of Hawaii (Abbott, 1992). Abbott chides "scholars (who) would be tempted to make a determination of which one among the various viewpoints was correct or normative," noting that "Hawaiian culture was diverse, more pluralistic than monolithic." She asks her readers to be researchers of family knowledge,

> We Hawaiians have mostly lost our once-great talent for the oral transmission of culture, so if stories of the old ways still reside in your family, search them out and treasure them—and make sure they are preserved in written form" (p. x).

Linda Smith (1999), a Maori researcher, describes 25 research projects being undertaken by indigenous peoples with "(t)hemes such as cultural survival, self-determination, healing, restoration and social justice" (p. 142). Story telling, indigenizing, connecting, writing, representing, and naming are 6 research projects implicitly embedded in Abbott's suggestion to Native Hawaiians to seek out, treasure and write their cultural stories.

A Native Hawaiian preservice teacher's assignment to write about her personal place produced the excerpt below that includes the joy of childhood experiences, the internalized voices of elders, Hawaiian place names and cultural uses of land, and a critique of recent changes in her personally lived environment. It suggests that asking teachers to reflect on a personal place could begin a transformation from thinking about science education as the delivery of impersonal content to thinking about it as experiential, real-world learning using a range of research methods and methodologies including those of mainstream science to develop environmental literacy and interest in science.

> Hanalei has all the elements that remind me of my youth in *Pupukea* on O'ahu—beautiful bay to swim in, valley to explore and to [play] around in. My cousins and I would explore all over the back country and visit *Pu'u Mahuka* and clean up the trash up there for fear that if we saw the trash and didn't pick it up, our ancestors would punish us. We would head down the hillside into *Waimea* Valley and quickly find ourselves playing in

the stream. We would look for any sort of creature to look at and float around toward the sea. The best was floating out to the ocean and being able to see the lush valley behind us. We are unable to do those sorts of things now since there are homes in the backcountry and there is ever-present danger of rockslides on the hillsides as well as *leptospirosis* in the stream that we used to play in…*Hanalei* reminds me of how things were in *Pupukea*, it has the beautiful lush valley with impressive and majestic mountains that surround it, (one peak fascinates me, *Hihimanu*, the giant manta ray). There is the *Hanalei* River to play around in and it also flows into the *lo'i* (taro pondfield) which is a reminder for me of what was important to my ancestors.

Study Population and Research Questions

Nineteen experienced secondary science and mathematics teachers, 8 females and 11 males, from Japan (3), Malaysia (5), Indonesia (1), Thailand (1), Korea (2), Philippines (2), United States (5) attended a 10 day workshop in Honolulu, Hawaii of which 2 days focusing on science curriculum were led by the author. The workshop topic, Trends in Science Curriculum, presented an opportunity to explore science and mathematics teachers' views of indigenous knowledge and sense of place from a cross-cultural perspective. Would a sequence of exercises exploring personal views and an introduction to indigenous cultural practices from a Hawaiian perspective provide a conceptual framework for transformational learning? The study explores three questions:

- What initial views do mathematics and science teachers hold of local and indigenous knowledge and how do these views influence teaching?
- Do reflective activities and exposure to Native Hawaiian practices oriented to sustainability lead to evidence of transformative learning with elements noted by Hall above?
- What environmental issues relevant to place-based curriculum are of concern to teachers?

Methodology

Five of 25 indigenous research projects described by Smith (1999) were employed in this study: indigenizing, connecting, writing, representing, and discovering. Indigenizing refers both to the re-visioning of cultural landscapes from the perspective of indigenous peoples and opposition to colonization through indigenous identity and practices. Connecting "positions

individuals in sets of relationships with other people and with the environment" (*ibid*, p. 148). Writing and representing empower indigenous peoples to represent their realities, issues, and identity. Discovering refers both to "development of ethno-science and the application of science to matters which interest indigenous peoples" *(ibid*, p. 160).

To develop texts for personal reflection and stories for group discussion, writing prompts directed teachers to write about: 1) views of indigenous science and relevance to curricula before and after seeing a presentation on Hawaiian cultural practices; 2) a personal sense of place; and 3) personal development of expertise. Following each writing exercise, groups of 3-4 teachers from different countries, discussed their writings, looking for similarities and differences. Groups reported their findings for whole class discussion. At the end of the inquiries, teachers were asked to think of topics that could be developed into place-based curriculum relevant to their students and communities. Teachers' writings were collected and notes taken of group discussions.

Findings

Writing, Representing, Discovering and Indigenizing Science Knowledge

Before seeing the presentation on Hawaiian cultural practices oriented to sustainability, teachers wrote for a few minutes on the prompts: "I think indigenous science is…" and "The role it has in curriculum is…."Following a PowerPoint presentation of traditional Hawaiian ecological practices related to farming, aquaculture, and conservation practices, teachers responded again to the same prompts.

A male Chinese teacher from Kuala Lumpur, Malaysia, wrote before seeing the presentation:

> Science has no or little place in (lives of) indigenous people – if at all they are used without being understood. Many herbal medications being used are passed down from generation to generation, knowing how to use but not why. The role it has in science curriculum is erroneous. Many traditional or herbal medicines required studies to have a full understanding and may have a great impact on modern medicine.
>
> Following the presentation, the same man wrote:
>
> It is about a balance between the mountain, the land and the sea – a diverse ecological balance. The role it has in science curriculum is to do things correctly and show the ways and means to sustain modern life.

A male teacher from Japan wrote before the presentation:

I think indigenous science is when catfish are nervous, big earthquake is coming. Every natural thing, tall tree, mountain, river, pond, large rock is house of Gods (spirit). Therefore we had 2,000,000 Gods all over Japan.

After the presentation, he wrote:

The idea of 'respect to the Nature' was gone when Japan meets Western culture and they found Japan is way behind the West. 'Gods are gone' for 100 years, 1867-1967. When we suffered serous air pollution, 'Gods came back' through education. After 1960, 'environment' and 'natural conservation' became major issues in science education. If you talk to professional people, carpenters, engineers, mechanics, you will find their own traditional and very practical math and science which is not taught in school and it is very interesting.

The groups synthesized and developed generalized analyses of their discussions. The following writing is typical of group reports:

The earth is our small and only livable planet. We should treat it with care so that the resources it provides for the human race are manageable and sustainable. Many traditional practices are invariably one way or another (related to) very effective ecological cycles one must pay attention to. The culture of indigenous people must be recognized and respected for its continued perpetuation.

Connecting to Others: Learning as Socially Situated

The writing prompt to describe how personal expertise develops asked teachers to examine their own stages of learning from initial interest to expert performance. After writing for 5 minutes, teachers from different countries met in small groups to discuss their writings and look for similarities and differences. Groups then reported their findings for class discussion.

Although the skills described by individuals ranged from teaching to skiing to cooking and growing hibiscus, the common patterns that emerged were: 1) Whatever was learned was important to one or more significant others in their lives; 2) learning was supported and encouraged by significant others; 3) practice, feedback and encouragement were important for improvement; 4) enjoyment, interest, and other emotions were important to learning; and 5) active and hands-on learning complemented learning from books and lectures.

As small groups shared their personal stories of developing expertise, international teachers who had only met each other a few hours earlier and were still uncomfortable speaking in English, for most a second even third language began to relax, offering nonverbal encouraging nods, smiles and laughter at each others' stories. These secondary science and mathematics teachers were recognizing how important positive emotions, affect, and connectedness to others are in learning.

Connecting to Place: Discovering A Sense of Place

The exercise intended to sensitize teachers who were initially critical of indigenous peoples' emotional and spiritual connections to place to the emotional aspects of their writings on personally important places. As in the other exercises, teachers responded to a prompt to write for 5 minutes about a personally meaningful place. They shared their writings in small groups and reported similarities and differences to the whole class. Although specific places with personal connections and meaning ranged from natural settings such as a beautiful beach to being inside a father's house, the places shared some common characteristics. The places were described in emotional terms as being comfortable, familiar, peaceful and secure.

Transformative Learning: Implications for Curricular Change

The final writing assignment employed the preceding exercises and discussions as a springboard for planning place-based, teacher-developed curriculum. Teachers who initially had not favored inclusion of indigenous knowledge and practices in the curriculum now thought it had value, as noted by Abbott earlier to teach students to stay connected to elders and traditional knowledge. Students would continue to learn and value their own cultural practices, connect to their environment through cultural practices and learn to treasure instead of exploit local natural resources and raw materials. They regretted that children in their rapidly developing nations already did not know how it used to be just a few generations ago. They faulted test-driven curricula for eliminating the joys of teaching and learning and having little connection to students and their lives. They thought national science and mathematics curricula should not be generic across countries and were of the opinion that individual countries should be proud of their own indigenous knowledge.

Asian teachers commented frequently on the loss of respect for the elderly and the displacement of traditional knowledge by modern, western models of science and mathematics

education. As a group, the international teachers expressed frustration at the irrelevance of the curricula and assessment adopted from former colonizers. They complained about feeling trapped in covering an extensive body of content. They said the curriculum was disconnected from real issues of students and their communities. Both international and U.S. teachers agreed that test-driven curricula did not support independent thinking, encourage learning about traditional knowledge and practices, or address local environmental issues.

Though the 2-day workshop did not allow time to develop ideas into written units or lesson plans, teachers identified issues of sustainability in their localities that potentially could be included in their curricula. Major issues were air pollution from unregulated vehicles and uncontrolled brush and forest fires (Malaysia), soil erosion and water pollution (Philippines), and dangerous driving behaviors on inadequate roads in the rapidly developing nations (Korea and Malaysia). A woman from the Philippines spoke about exploitative logging that left hillsides denuded and eroded and the people below vulnerable to landslides, flooding, and water pollution following heavy rains. The group discussed ways to incorporate local environmental issues into their curricula and discussed how data could be collected, analyzed and reported to policy makers to make changes leading to the common good.

Discussion

The findings of this study suggest that a presentation on indigenous practices and reflective writings on personal place, patterns of learning, and traditional practices provide opportunities for western trained science and mathematics teachers to bring culture and personal experiences into discussions of curriculum and pedagogy. Written comments by several Asian teachers initially devalued traditional practices, indicating the cultural dominance of western science and marginalization of indigenous science knowledge. Following a presentation on Hawaiian environmental practices oriented to sustainability that interpreted cultural practices from Western science perspectives, the same teachers appeared freer to speak as indigenous persons trained in Western modern science but still connected to and familiar with traditional, indigenous practices.

The Chinese teacher from Malaysia who initially dismissed indigenous science ("Science has no or little place in (the lives of) indigenous people – if at all they are used without being understood…The role it has in science curriculum is erroneous.") was still willing to consider the potential value of traditional herbal medicines following discovery of active principles

through science research. After the presentation on indigenous Hawaiian practices he understood indigenous science in a completely different light. He still wrote predominantly from the perspective of a non-indigenous person, but now thought indigenous science's role in science curriculum would be to connect students to the natural world from an ethical and ecosystems standpoint: "It is about a balance between the mountain, the land and the sea – a diverse ecological balance. The role it has in science curriculum is to do things correctly and show the ways and means to sustain modern life."

Before the presentation on indigenous Hawaiian practices, the teacher from Japan gave a folk science example of indigenous science, "when catfish are nervous, big earthquake is coming," and referred to traditional Shinto animism that imbued natural features with "2,000,000 gods." After the presentation he noted that "respect to the Nature (sic) was gone" and "Gods are gone" for 100 years while Japan was industrializing to catch up with the West. "Gods came back" through education only after the country began to suffer serious air pollution. His writing suggests that becoming westernized separated people from traditional beliefs and practices connecting them to their environment in a relationship of respect and reverence with negative consequences. The return of the gods represents re-indigenizing and discovery of the positive ecological effects of indigenous perspectives and behavior in the natural world.

This teacher knew and was proud that "professional people, carpenters, engineers, mechanics" were still using "traditional and very practical math and science which is not taught in school and it is very interesting." Writing as an indigenous person from a nation with its own cultural knowledge and practices, he implicitly critiqued his country's WMS school programs for excluding traditional, indigenous math and science knowledge. He represented this knowledge as so "very practical" that "professional people" even engineers with WMS training knew and used it. It appears from his comment "it is very interesting" that he also knew about it but unfortunately, there was not enough time to elaborate further.

As teachers shared and discussed their stories, traditional belief systems connecting people, places and natural phenomena were reevaluated in a more positive light as the wisdom and ethics of environmental ethno-science became apparent. In discussions following the sharing of cultural and personal experiences, teachers touched on the elements of transformative environmental education listed by Hall (2004) and began to formulate the concept of a lifeplace (Thayer, 2003) connected to cultural and ecological issues affecting their lives and the lives of

their students. This study suggests that transformative learning (Hall, 2004) "the process of learning…which is linked to changing the root causes of environmental destruction or damage" (pp. 170-171) develops when teachers connect their personal experiences and understanding of place to their professional roles as teachers and curriculum developers. Hawaii's teachers employ science and social studies standards concerned with the environment as a framework for curriculum development: *Malama I Ka 'Aina*, Sustainability and geography standard Environment and Society focus on limited resources, fragile ecosystems, active care-taking (*malama*) and stewardship (www.doe.k12.hi.us/standards/hcps.htm).

Unfortunately, even if teachers develop locally relevant, standards-based curricula, administrators fear that standardized tests will not overlap with curricula including local environmental issues and indigenous knowledge. These fears may lead to policies restricting teachers to mainstream texts covering content likely to be tested. As in the case of the elementary teacher who felt obligated to teach science foreign to Hawaii, teaching for environmental literacy and more democratic outcomes is marginalized to produce pseudo-experts (Sternberg, 2003). McNeil (2003) notes that teacher education and professional standards promoting student-centered pedagogy, constructivism, collaboration, problem solving and inquiry conflict with accountability as measured by standardized tests produced by "business [with] a new vision that there is money to be made…in meeting the clamor for choice, privatization, and testing" (p. 34). In the current test-driven climate in the U.S., localized, place-based curriculum is not likely to be sustained unless it also raises test scores. Whether it meets the needs of students and local communities or leads to environmental literacy may be considered of lesser importance.

Conclusion

At the start of the workshop, teachers tended to critique indigenous knowledge as possibly erroneous, based on superstition and empty ritual, and serving only as a negative example in science. After the presentation of Hawaiian cultural perspectives, teachers began to openly acknowledge the value of indigenous and traditional practices in teaching environmental sustainability. Written exercises followed by small group and whole class discussion helped teachers develop the concept of a personal sense of place and an awareness of the social contexts of learning. Discussions of the impact of WMS on their science and mathematics curricula led to critiques of western, test-driven models of science and mathematics curricula as colonizing and

irrelevant to pressing environmental issues related to economic development, globalization, exploiting of natural resources and marginalization of indigenous peoples.

The evidence of transformed views of science education was the teachers' recognition of a need for reinhabitation, "learning to live-in-place in an area that has been disrupted and injured through past exploitation (Berg and Dasmann, p. 35 cited by Gruenwald, 2003: 9). Negative attitudes toward indigenous knowledge and practices changed in the direction of respecting cultures that understand and care for their environments.

Gruenewald (2003) writes:

> If reinhabitation involves learning to live well socially and ecologically in places that have been disrupted and injured, decolonization involves learning to recognize disruption and injury and to address their causes. From an educational perspective, it means unlearning much of what dominant culture and schooling teaches, and learning more socially just and ecologically sustainable ways of being in the world.

Developing a personal sense of place and reflecting on traditional and indigenous knowledge oriented to place and sustainability appear to play a critical role in transformative learning leading to environmental literacy. For the highly diverse science and mathematics teachers in the workshop, revisiting traditional practices led to understandings echoing the Hawaiian proverb "*He ali'i ka'aina, he kaua ke kanaka*, the land is a chief man is the servant (Pukui, 1983).

References

Abbott, I. (1992). La'au Hawaii: Traditional Hawaiian uses of plants. Honolulu: Bishop Museum Press.

Bazerman, C. (1988). Shaping written knowledge: The genre and activity of the experimental article in science. Madison: University of Wisconsin Press.

Cajete, G. (Ed.) (1999). A people's ecology: Explorations in sustainable living. Santa Fe: Clear Light Publishers.

Cajete, G. (2000). Native science: Natural laws of interdependence. Santa Fe: Clear Light Publishers.

Cajete, G. (1986). Science: A Native American perspective: A culturally based science education curriculum. Unpublished doctoral dissertation, International College, Los Angeles.

Chinn, P. (2003). A Hawaiian sense of place: Science curricula incorporating Hawaiian ways of knowing. Paper presented at the NARST Annual International Conference, Philadelphia, March 23-26, 2003.

Chinn, P. (1999a). Isabella Aiona Abbott and the education of minorities and females. Teaching Education, (10), 155-167.

Chinn, P. (1999b). Multiple worlds and mis-matched meanings: Barriers to minority women engineers. Journal of Research in Science Teaching. 36(6), 621-636.

Chinn, P. (2003). What preservice teachers bring to the classroom: How sociocultural experiences shape future teachers of diverse learners. In Kendra Wallace (Ed.) Working with Mixed Heritage Students: Critical Perspectives on Research and Practice. Westport, CT: Greenwood/Praeger.

Chinn, P. & Sylva, T. (2000). *Malama i ka 'aina*: Using traditional Hawaiian and modern environmental practices to develop standards-based K-12 science curricula for teachers of Hawaiian and part-Hawaiian students. Award from the U.S. Department of Education, Office of K-12 Education Programs under Native Hawaiian Education Act.

Chinn, P. & Sylva, T. (2002). *Pikoi ke kaula kualena*, Focus on the essential core: Developing culturally relevant, standards-based science curricula for teachers of Hawaiian and part Hawaiian students. Award from the U.S. Department of Education, Office of K-12 Education Programs under Native Hawaiian Education Act.

Cole, M. (1996). Cultural psychology: A once and future discipline. Cambridge: Harvard University Press.

Daily, G. (2003). What are ecosystem services? In Lorey, D. (Ed.), Global environmental challenges for the twenty-first century: Resources, consumption and sustainable solutions. (pp. 227-231). Lanham, MD: SR Books.

Diamond, J. (2001). Unwritten knowledge. *Nature, 410*, 521-522.

Disinger, J. & Roth, C. (2003). Environmental Literacy. Eric Digest. Clearinghouse for Science, Mathematics, and Environmental Education. *November 1992 (Updated June 2003)* http://www.stemworks.org/digests/dse92-1.html accessed 5/20/05.

Fain, S. (2004). The construction of public space. In Callejo Perez, D., Fain, S., & Slater, J. (Eds), Pedagogy of place: Seeing space as cultural education. (pp. 9-33). NY: Peter Lang.

Garcia, E. (1999). Student cultural diversity: Understanding and meeting the challenge. Second Ed. Boston: Houghton Mifflin.

Gee, J., Hull, G. & Lankshear, C. (1996). The new work order: behind the language of the new capitalism. Boulder: Westview Press.

Gould, S. (1993). American polygeny and craniometry before Darwin: Blacks and Indians as separate, inferious species. In S. Harding, (Ed.). The racial economy of science: Toward a democratic future. (pp. 84-115). Bloomington, Indiana University Press.

Greenfield-Arambula, T. (2005). The research lens on multicultural science teacher education: What are the research findings, if any, on major components needed in a model program for multicultural science teacher education? Paper presented at the NARST Annual International Conference, Dallas, April 4-7, 2005.

Gruenewald, D.A. (2003). The best of both worlds: a critical pedagogy of place. Educational Researcher, 32(4): 3-12.

Hawaii Teacher Standards Board: Empowering teachers through excellence. http://www.htsb.org/standards/index.html accessed May 26, 2005.

Kanahele, G. (1986). Ku kanaka stand tall: A search for Hawaiian values. Honolulu: University of Hawaii Press.

Hall, B. L. (2004). Towards transformative environmental adult education: Lessons from global social movement contexts. In D. E. Clover (Ed.), Global perspectives in environmental adult education (pp. 169-191). NY: Peter Lang. .

Kanaiaupuni, S. & K. Ishibashi (2003). Left behind? The status of Hawaiian students in Hawai‘i public schools. PASE Report 02-02:13 www.hawaii.gov/gov/Members/Rhonda/e-Newsletter/Members/Rhonda/Documents/Left-Behind-PASE-Report-6.2003 retrieved February 28, 2005.

Kawagley, O. (2001). Living voice/voces vivas, Profiles. Oscar Kawagley, Vol 2, Track 5. Smithsonian Natronal Museum of the American Indian, August 2001. Retrieved March 10, 2005 from http://www.nmai.si.edu/livingvoices/html/eng_vol2.html.

Kawakami, A.J. and K.K. Aton. 2000. *Ke A'o Hawai'i* (critical elements for Hawaiian learning): Perceptions of successful Hawaiian educators. Pacific Education Research Journal 11(1): 53-66.

McNeil, J. (2003). Curriculum: The teacher's initiative. Third Ed., Upper Saddle River, J: Merrill/Prentice Hall.

National Research Council (1996). National Science Education Standards. http://www.nap.edu/readingroom/books/nses/html/3.html

Nisbett, R. (2003). The Geography of Thought: How Asians and Westerners Think Differently...and Why. NY: The Free Press.

Orr, D. (1992) Environmental Literacy: Education as if the Earth Mattered. Twelfth Annual E. F. Schumacher Lectures October 1992, Great Barrington, Massachusetts.

Palumbi, S. (2001). Humans as the world's greatest evolutionary force. Science, 293, 1786-1790.

Poepoe, K.K., Bartram, P. & Friedlander, A. (2003). The use of traditional Hawaiian knowledge in the contemporary management of marine resources. P. 328-339 *In*: Putting Fishers' Knowledge to Work, Fisheries Centre Research Report, University of British Columbia. Vancouver.

Pukui, M. (1983). *'Olelo no'eau*: Hawaiian proverbs and poetical sayings. Honolulu: Bishop Museum Press.

Pukui, M, Elbert, S., & Mookini, E. (1974). Place names of Hawaii, Rev. Ed. Honolulu: University of Hawaii Press.

Smith, G. (2003). Indigenous struggle for the transformation of education and schooling. Keynote address to the Alaskan Federation of Natives Convention. Anchorage, Alaska, October.

Smith, L. (1999). Decolonizing methodologies: Research and indigenous peoples. New York: Zed Books Ltd.

Snively, G. & Corsiglia, J. (2000). Discovering indigenous science: Implications for science education. Science Education, 85:6-34.

Song, J. (2005). Isles tops in count of species in danger. Honolulu Star-Bulletin, Tuesday, May 17.A9.

Sternberg, R. (2003). What is an "expert student"? American Educational Research Journal, 32(8) 5-9.

Takaki, R. (1993) Aesculapius was a white man: Race and the cult of true womanhood. In S. Harding, (Ed.). The racial economy of science: Toward a democratic future. (pp. 201-209). Bloomington, Indiana University Press.

Thayer, R. Jr. (2003). LifePlace: Bioregional thought and practice. Berkeley: University of California Press.

The geography of thought: How culture colors the way the mind works. News Service, University of Michigan, February 27, 2003. http://www.umich.edu/news/Releases/2003/Feb03/r022703a.html. Accessed 2/29/04.