Sustainability Science Education:
Implications for Teacher Education from Indigenous Hawaiian/Local Perspectives

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Abstract

Native Hawaiian students often develop extensive ecological knowledge through informal and non-formal cultural and subsistence practices. This knowledge seldom connects to mainstream school science developed for middle class students in the continental US. Documents and interviews suggest that displacement of Indigenous knowledge, values, and practices contribute both to the underrepresentation of Native Hawaiians in science and the decline of sustainable social-ecosystems. Four elements contributing to a Hawaiian cultural model of sustainability provide the framework for professional development oriented to sustainability: 1) a Hawaiian sense of place, 2) mālama, active care for a familiar place; 3) kuleana, responsibility; and 4) active inquiry situated in real world issues. Place-based lessons incorporating these elements orient science learning to sustainability, a fundamental cultural goal. Teachers often transform their instruction when they recognize that students’ informal and non-formal knowledge and practices are resources for science education. The paper concludes that reestablishing Mālama I Ka ‘Āina, Sustainability, as a Hawai‘i State science standard would connect formal to informal and non-formal science knowledge, support systems thinking, and engage students in problem solving and civic action for the common good.

Keywords: Sustainability, sense of place, cultural landscape, Indigenous science


**Introduction**

I am fortunate to have been born and raised in the ecologically isolated Hawaiian Islands where Indigenous appreciation of and reliance upon fragile ecosystems supported a systems-oriented view of the world. Society and natural world composed a social-ecological system in which deep knowledge of place and constant monitoring permitted real-time, local decision-making oriented to sustainable practices. Formal social structures and processes allowed for the periodic integration of local knowledge across wider geographical and political units. Knowledge was not static but continuously updated and adapted for changing conditions. As appropriate in a sustainable, dynamic island society, place-based knowledge was associated with an ethic of care (*mālama*) and responsibility (*kuleana*) that supported a resilient, sustainable social ecological system.

However, as a K12 public school student, science teacher and educational researcher, my experiences show that mainstream school science continues to be dominated by Eurocentric perspectives conveyed in textbooks designed for students in the continental US (Chinn, 2011, 1999b). For the past decade, my work as a science teacher educator has centered on Indigenous Hawaiian knowledge and practices and their potential to inform, extend, and expand ways for science educators to learn and to teach (*aʻo*) in ways oriented to science literacy and sustainability.

Many Native Hawaiians reside in rural communities in which culturally grounded and subsistence lifestyles contribute to extensive ecological knowledge that seldom connects to school science. Throughout their schooling they are more likely to have teachers who are Japanese (29%) or Caucasian (23%) than Hawaiian/Part Hawaiian (9%) (Hawaiʻi State Department of Education, 2009). Castagno and Brayboy’s (2008) review of the literature on culturally responsive schooling led them to write: “The most obvious, but also most lacking, knowledge among teachers is an awareness and understanding of Indigenous cultures, histories, and political issues” (p. 972).
Cultural factors may contribute to these statistics: Hawaiian/Part-Hawaiian students, 28% of Hawai‘i’s public school population, scored 11% lower in math and 10% lower in reading than students statewide, even slightly lower than economically disadvantaged students on the Hawaii State Assessment examinations (Hawai‘i Department of Education, 2010).

A sense of place story illuminates the intersection of culture, science, and education. Dr. Isabella Kauakea Aiona Abbott, the first Native Hawaiian woman to earn a PhD in natural science, a world authority on marine algae, and my mentor in Indigenous science education, said being Hawaiian was first among her identities as scientist, university professor, wife, and mother (Chinn, 1999a). Years later, I saw what this meant when I visited her laboratory and saw a small banana plant in a bucket shortly before a NOAA research and education cruise to a part of the State of Hawai‘i that was proclaimed the Northwestern Hawaiian Islands Marine National Monument in 2006, renamed Papahānaumokuākea National Monument in 2007, and registered as Papahānaumokuākea, a World Heritage site July 30, 2010 (http://whc.unesco.org/en/news/640). Dr. Abbott said it was appropriate to notify the akua, gods, and aumakua, ancestral gods, associated with these places of the arrival of visitors. The captain approved Dr. Abbott’s request to offer the banana plant, symbolizing Kanaloa, god of the sea (Abbott, 1992). Sabra Kauka, a cultural practitioner/science educator presented the offering when they reached the islands.

This paper will address three questions relevant to environmental science education:

- What is the deeper meaning of Dr. Abbott’s offering of a banana plant?
- What role may Indigenous Hawaiian cultural practices and values supportive of adaptive learning play in science education oriented to sustainability?
- What role may place-based teacher education play in supporting science education oriented to sustainability?
Before addressing these questions the following sections provide an overview of major US educational ideologies, introduce place and culture-based education, and develop the concepts of sense of place, mental models, and cultural landscapes.

**Locating Place-Based Education In Western Schooling**

Schiro (2008) views US education as guided by four major Western ideologies: *scholar academic* focused on acquisition of disciplinary knowledge; *social efficiency* focused on efficient preparation of learners to be productive members of society; *learner centered* focused on experience-based preparation for the future; and *social reconstruction* focused on problem finding and problem solving in an imperfect world. All are anthropocentric, human-centered versus ecocentric, integrating human and natural worlds, but at least the last two engage students in active, place-based learning. Sternberg’s (2003) research suggests that the ideology adopted in schools has implications for student learning and society. His findings show that assessment emphasizing content mastery favors the success of middle class, mainstream students and produces what he calls *pseudo-experts* lacking the practical experiences needed to develop critical thinking and real world problem-solving skills.

Fairclough (2006) holds that “people need resources to examine their placing…between the global and the local…and need from education a range of resources for living within socially and culturally diverse societies” (p. 151). Education providing the cross-level, transdisciplinary experiences that enable students to understand their placing between the local and the global is guided by sociocultural theories that view learning as developing through situated, context-rich, social interactions (Lave & Wenger, 1991). People who learn together in diverse learning communities focused on common interests participate in practices in which “members of these communities labor to produce new knowledge” and develop “common pools of knowledge—the knowledge commons” (p. 161, Waters, 2006).
Gruenewald (2008) provides a place and problem-based curriculum planning guideline: “What needs to be transformed, conserved, restored, or created in this place...[could] provide a local focus for socioecological inquiry and action that, because of interrelated cultural and ecological systems, is potentially global in reach” (p. 149). This human-in-ecosystem view recognizes interconnected social and natural systems as “complex adaptive systems where social and biophysical agents are interacting at multiple temporal and spatial scales” (p. 1465, Janssen & Ostrom, 2006). Woodhouse and Knapp’s (2000) review of North American school programs showed common characteristics despite each program’s unique, place-based nature: 1) natural and historical-cultural content specific to place; 2) multidisciplinary approaches; 3) experiential and/or service learning; 4) broader focus than preparation for a technological and consumer-oriented society; and 5) understanding of place, self, and community as part of a social-ecological system. They suggest place-based learning provides “knowledge and experiences needed to actively participate in the democratic process” (p. 33).

Hall’s (2004) review of global adult environmental education programs suggests a more critical, cross-cultural stance in its characteristics: 1) a sense of place, 2) valuing of biodiversity, 3) connection with nature, 4) revitalization of traditional and indigenous knowledge and practices; 5) building of social networks; 6) understanding of power-knowledge relationships; and 7) valuing learning from elders. Hall’s findings are particularly relevant to place-based science education programs in Hawai‘i that incorporate revitalization of traditional and indigenous knowledge and practices and a uniquely Hawaiian sense of place.

Place-based learning that includes non-formal learning associated with cultural activities such as fishing and farming and informal learning associated with day-to-day experiences holds the potential for Hawai‘i’s educators to recognize and connect community and culture-based non-formal and informal “funds of knowledge” (p. 134, Moll, Amanti, Neff, & Gonzalez, 2001) to
formal science learning. An Organization for Economic Co-operation and Development (OECD, 2010) policy paper notes that recognizing informal and non-formal knowledge can provide economic, educational, and social benefits by “allowing human capital to be used more productively,” “improving equity and…access to…education,” “making individuals aware of their capabilities and validating their worth” (p. 1) and encouraging life-long learning.

**Hawaiian Sense of Place: A Cultural Model Oriented to Sustainability**

Sense of place is a concept employed across a range of disciplines to connect human experience to constructed and natural settings. Craik (1943) first proposed the notion of a mental model as a representation of external reality coupling knowledge of past events with scenarios of possible actions, enabling response to potential crises. Nisbett and Norenzayan (2002) observe that “Cultural practices encourage and sustain certain kinds of cognitive processes, which then perpetuate the cultural practices” (p. 3). Jackson (1984) a geographer, views place as shaping personal identity: “It is place, permanent position in both the social and topographical sense that gives us our identity (p. 152). A sense of place is thus a culturally shaped mental model, a way of thinking about the world and how to act within it with implications for identity.

Maly (2001) describes a Hawaiian sense of place as “the intimate relationship (developed over generations of experiences) that people of a particular culture feel for the sites, features, phenomena, and natural resources etc., that surround them” (p. 1). A Hawaiian sense of place reflects cultural and familial relatedness with the power to shape values and behavior:

Hawaiian customs and practices demonstrate the belief that all portions of the land and environment are related, like members of an extended family...Just as place names tell us that areas are of cultural importance, the occurrence of a Hawaiian nomenclature for environmental zones also tells us that there was an intimate relationship between Hawaiians and their environment (p. 3).
A Hawaiian sense of place as described by Maly and enacted in Dr. Abbott’s offering to ancestral gods demonstrates a *kanaka maoli*, Indigenous Hawaiian, understanding of humans as part of a social-ecosystem integrating culture and nature. Abbott (1992) writes, “Hawaiians did not belong to a village but rather to an *ahupua’a*, a land division extending from the mountain heights to the sea” (p. 11). People lived sustainably within their *ahupua’a* through a system of *mauka*, upland-*makai*, coastal exchange. Hawaiian place names (Pukui, Elbert, & Mookini, 1974; Clark, 2002) associated with resources and nature gods seen in natural phenomena created storied, historical landscapes in which myth and reality entered “into all the affairs of daily life” (p. 2, Beckwith, 1940/1970). Many stories, *mo‘olelo*, such as those of the gods of fishing (*Kū‘ula*) identify “authentic fishing grounds and stations for fishermen in island waters” (p. 20, *ibid*) and describe fish aggregation and spawning sites.

A traditional *‘ōlelo no‘eau* (proverb), “*He ali‘i ka ‘āina he kauwā ke kanaka*; the land is a chief, man is its servant” (531) expressed the *kanaka maoli* relationship between humans and the land that sustained life. George Kanahele (1986) explained this core difference between Hawaiian and western worldviews when he wrote: “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 ‘āina and kai, trusted to take care of these islands on behalf of the gods, our ancestors, ourselves, and our children” (p. 208).

The definition of nature below from Webster’s II New Riverside University Dictionary (Riverside Publishing Company, 1984) reveals that in a western worldview culture and nature are separated and humans are not among the “processes and forces that produce and control all the phenomena of the material world”:

Nature: n. [ME, essential properties of a thing < Lat *natura* < *nasci*, to be born] 1. The material world and its phenomena. 2. The processes and forces that produce and control all
the phenomena of the material world. 3. The world of living things and the outdoors (p. 786).

In contrast, the Hawaiian language has no words for nature or environment in the sense of a world outdoors or physical universe (Pukui & Elbert, 1986). Kanahele’s statement above, “a person belonged to the land” inverts Eurocentric views of humans having dominion over nature and, in the context of a worldview oriented to sustainability, unites economics and ecology as complementary concepts. These ideological differences between dominant western and historically marginalized Indigenous worldviews are examples of Harding’s (2003) observation that “all knowledge systems, including modern sciences contain at least traces of their particular histories and ongoing practices; they are all ‘local knowledge systems’ in this respect” (p. 58). She concludes that “all four conditions of inquiry processes—location in nature, interests, discourses, and ways of organizing inquiry—are shaped by a culture’s (or subculture’s) ‘location’ in social relations” (p. 59).

As noted by psychologists Nisbett and Norenzayan (2002) and philosophers of science, an individual’s location within a social system “systematically shapes and limits what we know, including tacit, experiential knowledge as well as explicit understanding” (p. 31, Wylie, 2003). In the context of American economic and political expansionism (Office of the Historian, http://history.state.gov/milestones/1866-1898/Hawaii), it is not surprising that within 200 years of western contact in 1778, Hawai‘i transitioned from a sustainable society to one importing 85% of its food and 95% of its energy (Hawai‘i Sustainability Task Force, 2008).

Hawaiians commented on this transition in more than 100 Hawaiian language newspapers published from 1834-1948 (Silva & Badis, 2008). “Saving the Fish” (Ka Nupepa Kuokoa, 1923) illuminates the role of competing cultural models in sustainability practices. The writer deplores the decline of fisheries within his own lifetime and notes that sustainable fisheries were maintained by a kapu system enforced by harsh penalties. Prohibiting fishing during the spawning season and
specific months, allowing only those with recognized rights to fish, restricting favored sea foods to men or high ranking individuals, construction and maintenance of a variety of fishponds (Titcomb, 1952/1972), and discouraging a taste for fish roe (Titcomb, 1952/1972; Barrows, personal communication) were ways to conserve and augment marine resources.

After US annexation in 1898, traditional resource management systems were abolished as commercial fishing and open access to formerly restricted areas became the law of the land. But Indigenous Hawaiian views of sustainability persist as seen in a 1994-2005 Hawaiian science content standard “Mālama I Ka ‘Āina, Sustainability;” a new ‘ōlelo no‘eau, “The ocean is our refrigerator;” biorestoration of Kaho‘olawe Island, a former military bombing target guided by traditional practices and values (Gon, 2003); and the Hawai‘i 2050 Sustainability Task Force’s (2008) report recommending that citizens “Preserve and perpetuate our Kanaka Maoli (Indigenous Hawaiian) and island cultural values” (p. 12).

**Sustainability Science Education: Mālama I Ka ‘Āina**

Recognizing the need to understand complex, cross-scale interactions in linked human and natural systems, the US National Research Council (NRC, 1999) prioritized development of a “research framework that integrates global and local perspectives to shape a ‘place-based’ understanding of the interactions between environment and society” (p. 10). Coupled social ecosystems began to be understood as complex systems susceptible to tipping points, defined as “The point at which a system undergoes a drastic change from one state to a very different one; complex systems involving positive feedback among components with non-linear rates of change are susceptible to tipping point phenomena” (p. 53, NSF Advisory Committee for Environmental Research and Education, 2009). The United Nations report *Biodiversity Outlook 3–Executive Summary* (2010) conveyed similar concerns:
No one can predict with accuracy how close we are to ecosystem tipping points, and how much additional pressure might bring them about. What is known from past examples, however, is that once an ecosystem shifts to another state, it can be difficult or impossible to return it to the former conditions on which economies and patterns of settlement” (p. 8).

The UN report noted that “loss of biodiversity is frequently linked to the loss of cultural diversity and has an especially high negative impact on indigenous communities,” (p.7) and recommended support for “effective ‘bottom-up’ initiatives…empowering indigenous peoples and local communities to take responsibility for biodiversity management and decision-making” (p. 9).

Dudgeon & Berkes (2003) note that sustainability, defined as “the ability to continue or persist into the long-term while maintaining a particular set of characteristics or functionalities” (p. 53, NSF, 2009) depends on a society’s ability to deal effectively with change. The coupling of place-based knowledge of resources and human behavior suggests that traditional Indigenous Hawaiian culture exhibits hallmarks of “complex adaptive systems that include components having the capability to learn from experience…and change in response to overall system level behavior” (ibid).

Sustainability of Indigenous Hawaiian social-ecosystems relied upon long term, organized, place-based knowledge constantly updated through monitoring, analysis, and action before tipping points were reached. Maly’s (2001) translation of a 1916 Hawaiian language newspaper article recording the response to a riddle reveals an eco-cultural map integrating nature, gods, and culture in a uniquely Hawaiian landscape. Beckwith (1940/1970) observes that riddling competitions “between masters of learning” (p. 462) across Polynesian cultures were tests of knowledge in which the loser might pay with his life.

Maly’s translation (p. 3) describing 23 wao (zones) of the Island of Hawai‘i underscores the ecological knowledge required to live sustainably within ahupua‘a spanning mountaintop to open
Resource managers, *konohiki*, had to integrate knowledge of interacting human and natural systems across levels of organisms, populations, communities, ecosystems, and biomes (Odum & Barrett, 2005):

1–The mountain; 2–The region near the mountain top; 3–The mountain top; 4–The misty ridge; 5–The trail ways; 6–The inland regions; 7 and 8– The rain belt regions; 9– The distant area inhabited by gods; 10–The forested region; 11–The region of people below; 12–The place of ‘ama’u [fern upland agricultural zone]; 13– The arid plains; 14–The place of wet land planting; 15–The plain or open country; 16–The place of *‘ilima* growth [a seaward, and generally arid section of the *kula*]; 17–The dunes; 18–The place covered by waves [shoreline]; 19–The shallow sea [shoreline reef flats]; 20–The dark sea; 21–The deep blue-green sea; 22–The yellow [sun reflecting– sea on the horizon]; and 23–The deep purplish black sea of Kāne at Tahiti. *(Ka Hoku o Hawaii, September 21, 1916)*

Hawaiian landscapes as detailed cultural maps co-developed with procedures for monitoring, organizing, and transmitting ecological information across scales from *ahupua’a* through entire islands. Abbott (1992) notes the role of the *Makahiki* in protecting natural resources. The *Makahiki na o Lono*, an island-wide, annual ritual dedicated to Lono, god of crops and bringer of rain began in late fall following the appearance of the Pleiades. For approximately four months marked by the rising of *Makali‘i*, the Pleiades in October, war, most fishing, planting, and other forms of work ceased as the island’s ruling chief, *mō‘i*, retinue and priests circled the island, visiting each *ahupua’a*. Decisions oriented to sustainability united ecology, economics, values, and practices: rights to resources were associated with responsibility, *kuleana* and active care, *mālama*.

Maly (2001) suggests that Indigenous resource management “incorporating traditional knowledge with modern sciences and planning approaches would benefit all members of our island
If society and nature are understood to be coupled human-in-ecosystems with “components having the capacity to learn from experience…and change in response to overall system level behavior” (p. 53, NSF Advisory Committee for Environmental Research & Education, 2009) the system becomes an adaptive learning system potentially able to couple learning with appropriate behavior. Place and problem-based inquiry oriented to sustainability crosses disciplinary boundaries and organizational levels and supports resiliency, “the ability to recover from disruption, or the rate of its return, to some prior state following a perturbation” (ibid). In the following section, educators in a Hawaiian culture based science education project describe their personal search for a *kanaka maoli* approach to science inquiry.

**Indigenous Inquiry and Science Education: Perspectives from Educators in Hawai‘i**

In 2010 science teachers, an archeologist/educator, and the author shared ideas on Hawaiian indigenous inquiry (Chinn, Abbott, Barrows, Kanahele-Mossman, Kapaña-Baird, Kauka, Lee, Lelepali, Ross, Walk, In press). Except for Moana Lee, each was a past or present educator in EDCS 433 Interdisciplinary Science Curriculum, *Mālama I Ka ʻĀina, Sustainability*, a place and culture-based curriculum development course. The following section presents six major themes related to Indigenous practices and science education, closing with Matt Kanemoto commenting on aspects of the course that help teachers understand how to connect community and culture-based non-formal and informal knowledge to sustainability science education.

1. **Role of hula, chants, ʻōlelo noʻeau, and moʻolelo**

Four Indigenous Hawaiian educators describe how traditional narratives containing ecological knowledge supported current inquiry and ways of acting in the world. According to Moana Lee, “Moʻolelo kept alive through hula are so much a part of indigenous research methods. There’s a red flower [no longer seen] in a hula I was learning. What a loss that we still have our language but not the land to tie it to.” Sabra Kauka spoke about taro, *Colocasia esculenta*, the
staple food plant considered ancestral to *kanaka maoli*: “Legends… hold clues to our purpose and place in this world. Perhaps the most important is that of *Hāloa*, the first born *kalo* plant. We take care of *Hāloa* as the elder sibling; once we lose that plant we too will be gone.”

Huihui Kanahele-Mossman elaborates:

That is the difference between scientists and Hawaiian practitioners—you both hear the song, but when we cannot see what is being referred to. It hurts us because our chants are also our genealogies….Our sources of research are these living things in our songs and stories, as books, journal articles and research studies are sources of information for western scientists… In the *Pele* and *Hi‘iaka* chant, *Polihua* is a beach on Lanai and *hua* is an egg, so this beach is probably a nesting site for *honu* (green sea turtles). So in this small section of a chant you learn the location of a beach that had a turtle’s nest and therefore know the characteristics of this beach. Information in the hula tells us why it is an important place to observe.

Ka‘umealani Walk describes how Indigenous ways of knowing and inquiring develop transdisciplinary, systems-oriented understandings:

We’ve chosen water quality, so we when we revitalize a *lo‘i kalo* (taro pond field) we’ll have questions, “What do we need to do today, what did they do back then, how do we know we’ve done a good job, who do we answer to?” Those simple questions take us back to an indigenous methodology: who we answer to in order to maintain the integrity. We really have to look at ‘ōlelo no‘eau as coded messages from the past: “Ma ka hana ka ‘ike; In working one learns.” We recognize different forms of knowledge, ‘ike, spiritual as well as intellectual/temporal ‘ike, and to be indigenous both have to be present…So you know how our people believed everything is alive, everything has a spirit. People talk about energy and cycles. So systems on land coordinated with systems in ocean, they were
coordinated with the lunar systems, and so forth. So that’s the science. It comes with 
kuleana (responsibility); and that ‘ike transferred from one generation to the next. I don’t
think western science understands the pivotal understanding that both must be present.

2. Role of Indigenous identity and cultural expectations

Napua Barrows, an elementary Hawaiian Studies teacher describes how being given
responsibility for family lands then years later learning to remove alien limu (seaweed) in a EDCS
433 workshop connected her family mandate to her instruction.

I thought [the native limu] should be restored. [Now] I work with limu restoring, replanting,
since the area I live on Maui is where my tutu is from and I learned the family moʻolelo.
She took me around, showed me all the lands and gave me the kuleana to take care of this
family land--little did I know that it covered the whole area. What I take care of at Waiheʻe
has extended to all of Maui and connected with other islands. I felt it was necessary for us
to expand with our Hawaiian Studies Program. It has generated a lot of excitement--we
work with the communities, get the kids involved…We were raised with some of it and
we’re ready to get back. And I can hear my grandmother. That’s where the knowledge is
waiting there for us if we open that door. Then you have to go with it after that, you just
can’t drop it.

3. Role of place-based cultural practices

Interaction with and knowledge of place are culturally inseparable from responsibility,
kuleana, and active care, mālama. For two decades Sabra Kauka and Moana Lee have worked to
monitor and restore Nuʻalolo Kai, a culturally significant site that “shows the longest continuous
sequence of occupation on Kauaʻi” (p.10, Abbott, 1992). According to Sabra:

Nu‘alolo Kai chose us. In 1992 we took back our first re-interment as a result of the Native
American Graves Protection and Repatriation Act (NAGPRA). These iwi (bones) came
home and we took them back to their place of origin. The trail was only a goat trail, so overgrown you couldn’t see very far, so the kūpuna led us there. We realized that we needed to begin to mālama that special ‘āina, we had to clean and clear. Nu‘alolo Kai is still dynamic. We are studying it hoping to once again to live that place and bring others in to live that place, even if for a short period at a time.

Moana, the archeologist-educator continues the thought of re-inhabiting ancestral lands: Other places are restored and people go there, but you don’t have the idea of it as having once being settled. But Nu‘alolo Kai, maybe because we spend so much time there, you feel that you are walking in someone else’s shoes, and this is why we return. Perhaps as we use it we evolve into who we are.

4. Role of Indigenous knowledge and practices in curriculum design and implementation

Michelle Kapana-Baird teaches both satellite navigation (global positioning system) technology as well as non-instrumental methods of locating sites in her Maunalua Bay invasive seaweed removal project.

Recently our students were in charge of invasive algae cleanup. A member of the community organization asked, “What are your GPS markings?” I said, “I don’t have one today.” “So how do you know it’s accurate? I knew she wanted to know how wide my area was that I cleared, what are the markings of my site, what are the points….These things, it’s all the science. So I told my student, “Mele, Hawaiians didn’t have GPS. This is what Ka‘au told me when we use to sail into Kualoa. This is what I learned how to sail into the harbor. You’d find a high land mark and a low land mark.” And I know the lady is listening to me. “How do you line it up and how will you see something that you will remember? What is a good landmark and what makes sense to you?” So I asked her to line it up with the hālau, (canoe house) a coconut tree, the Norfolk tree and the mountain….So Mele you have the
hālau and the trees and the mountain on this side and on the other side the dome and the mansion.” The lady came to me and said, “You triangulated your sights, I know you know what you’re doing.”

Mahina Hou Ross, a Hawaiian language immersion teacher on Moloka’i integrates traditional, place-based practices in his standards-based science lessons.

Uncle Mac Poepoe of Mo’omomi says, “If you can teach the kids what the kūpuna taught us, we have a chance.” So we made a moon calendar. We have four sites we visit each quarter, Mo’omomi Bay and three fishponds. The kids actually see the health of the different parts of Moloka‘i, more invasive limu along the south shore. The reef is not too healthy compared to Mo’omomi and further east. We take students into the water, look at the fish and check what they’ve been eating. Like kole (Ctenochaetus strigosus), cut them open to check. To get the cycles and seasons for spawning, what time of the year, you’ve got to cut them open to find out. Then you’ve got to eat, so we fried them up. And the standards are going to be there, so show the learning is standards-based --they see the relevance of the curriculum when they go hunting, fishing, diving.

5. Institutional, cultural, and societal barriers to Indigenous inquiry

Institutional barriers to place-based, indigenous methods of inquiry include school schedules interfering with community-based learning, high stakes tests discouraging time-intensive inquiry projects, and inadequate culture-science learning in teacher education courses. Other barriers include degradation of familiar places and urban, consumer-oriented lifestyles disconnected from place and traditional knowledge and practices.

Moana Lee had to overcome cultural barriers against western science raised by members of her Hawaiian community:
I started out as a scientist. About 25 years ago I was at a public meeting. One of the things being rejected by the Hawaiian community was science. Scientists are no good. Science was outright rejected because it had nothing to do with culture. I remember standing up. I was there to say something, as they were all rejecting science. My grandmother was a nurse, a healer. And you guys don’t like science, but my grandmother was a scientist, she observed, she asked questions. She came to her conclusions out of her observations. If you think science is not Hawaiian, you’re wrong. We would still be in the dark ages, we wouldn’t even know how to sail the ocean. I was very unpopular.

Sabra Kauka notes that developing transdisciplinary, place-based curriculum requires overcoming disciplinary specializations: “Another challenge is combining science, education and culture. The Canoe Plants Project took about two years and required the expertise of three different people. An NSF fellow provided scientific knowledge, a GK-12 graduate student wrote the lesson plans, and I provided the cultural component.”

6. Teacher education supportive of sustainability science education

Ag-science teacher Matthew Kanemoto writes about aspects of EDCS 433 that helped him and other teachers to transform their teaching:

[Teachers] get to see, smell, feel and do. We built a bioremediation system for the agriculture program at Kohala High School and re-established lo‘i that were over one hundred years old. We visited Konawaena High School where Maverick Kawamoto built a bioremediation system that uses watercress, aquatic plants, kalo and mollusks to clean the nitrogen rich effluent water from their fish tanks and cooked our food in an imu (underground oven). We visited the Amy Greenwell Gardens in Kona to learn about native plant propagation and sustainable practices the Hawaiians used to grow kalo, ʻuala (sweet potatoes) and ʻulu (breadfruit) on the dry Kona hillsides. At the end of the road at Ke'e
Beach, Kaua‘i students danced hula and gave *hoʻokupu* at Laka's hula pā that is over 1,100 years old. On Oahu, students learn about invasive limu identification and removal from Michelle and her Kaiser High School students, visit the Koko'ula Natural Resources program at Kahuku High to learn how to grow native Hawaiian plants, and stay at Coconut Island's UH Mānoa's Hawaiʻi Institute of Marine Biology to study critical issues affecting our world's oceans.

Educators take what they have learned and apply it in their own classrooms and communities... placed-based learning. Hawaiian placed-based education can open up and unlock the hearts and minds of our local Hawaiian students and bring relevance and meaning to science concepts and curriculum by drawing upon what our kids already know and love... the ‘āina and the kai.

**Discussion**

Three questions oriented the writing of this paper. The first, “What is the deeper meaning of Dr. Abbott’s offering of a banana plant?” may now be addressed in light of understandings of culturally-shaped mental maps (Nisbett & Norenzayan, 2002; Craik, 1943) and standpoint theory (Harding, 2003; Wylie, 2003) that view inquiry, values, and knowledge as being shaped by location and experiences in particular socio-ecological settings. As a prominent scientist and as a self-identified Indigenous Hawaiian, Dr. Isabella Aiona Abbott’s presentation of an offering of great cultural significance and its delivery from a NOAA (National Oceanic and Atmospheric Administration) research vessel signified the meeting and integration of two cultural knowledge systems. The protocol carried out by Sabra Kauka, a cultural practitioner/educator symbolically challenged the “assumption that modern Western science alone has the most desirable resources with which to grasp nature’s order” (p. 55, Harding, 2003), reestablished the Northwest Hawaiian Islands as a Hawaiian place, and returned an understanding of the interconnectedness of human,
natural, and spiritual worlds bringing with it responsibilities of stewardship and care as noted above by Kanahele (1986), Abbott, (1992), Maly (2001) and Hawai‘i educators.

The second question, “What role may Indigenous Hawaiian cultural practices and values supportive of adaptive learning play in science education oriented to sustainability?” is answered by the continued persistence of Indigenous Hawaiian cultural values and practices oriented to biological conservation and restoration. The adoption of a Hawaiian saying, Mālama I Ka ‘Āina, Sustainability as a state science standard in 1994 recognized that values and practices of Indigenous Hawaiians combined science literacy with a sustainability ethic and sought to connect formal, non-formal, and informal learning. The Secretariat of the Convention on Biological Diversity (2010) observes that

Biodiversity is at the centre of many religions and cultures, while worldviews influence biodiversity through cultural taboos and norms which influence how resources are used and managed …Through the application of traditional knowledge and customs unique and important biodiversity has often been protected and maintained in many of these areas over time (p. 40).

To overcome barriers to cultural systems that differ from dominant Eurocentric models, Harding (2003) recommends that we begin with a critical understanding of our own knowledge systems as the first step towards understanding others. Comments by Hawai‘i’s science educators indicate that teaching within an education system that does not fully recognize a multi-science world presents challenges. They speak of the importance of participating in diverse communities of practice, learning from elders, and developing a multifaceted sense of place grounded in lived experiences, cultural stories, and authentic inquiry. Their efforts to connect mainstream school science to Indigenous science resonate with Hall’s (2004) findings from global environmental education programs: awareness of power-knowledge relationships, revitalization of traditional
practices, developing a sense of place, knowledge of biodiversity, and importance of supportive, educative social networks.

The third question, “What role may teacher education play in supporting science education oriented to sustainability?” is answered by teachers who comment on the importance of professional development that 1) integrates culture and science, 2) provides models of sustainability science programs, 3) emphasizes a sense of place, and 4) enables participation in cultural practices relevant to sustainability. Participating in a community of practice enables culturally diverse participants to co-teach, co-learn, and develop new knowledge. Teaching and learning, concepts that differ in power and knowledge and oppose each other in English are unified in the Hawaiian word *aʻo*, meaning both to teach and to learn (Pukui & Elbert, 1986).

Teachers who recognize science inquiry and knowledge building as socially situated endeavors are more likely to recognize and incorporate their students’ informal and non-formal “cultural and cognitive resources with great potential (sic) utility for classroom instruction” (p. 134, Moll, et al, 2001). Teachers able to access these “funds of knowledge” (*ibid*) have more ways to engage diverse students by connecting home and community-based local and Indigenous practices to formal science education. As noted above, recognizing informal and non-formal learning can provide educational, economic, social and psychological benefits to underrepresented groups and alienated youth (OECD, 2010).

*Implications for Place-based Teacher Education and Curriculum Design*

Odum and Barrett (2005) write: “There is an increased need to solve problems, promote environmental literacy, and manage resources in a transdisciplinary (sic) manner involv[ing] entire education and innovation systems” (p. 16). Warning that “The loss of biodiversity is frequently linked to the loss of cultural diversity, and has an especially high negative impact on indigenous communities” (p. 7) the Secretariat of the Convention on Biological Diversity (2010) recommends
“communication, education and awareness raising to ensure that as far as possible, everyone understands the value of biodiversity and what steps they can take to protect it, including through changes in personal consumption and behaviour” (p. 12).

In Hawai‘i, place and culture-based science teacher education, curriculum and pedagogy, community values and actions continue to be guided by Mālama I Ka ‘Āina, Sustainability despite its displacement as a science content standard. Indigenous approaches inform numerous community groups in Hawai‘i dedicated to caring for particular places, laws concerning land and water rights, and plans to restore Kaho‘olawe Island. Place and culture-based professional development supports teacher agency by linking Indigenous roles to relevant science content and a network of community practitioners. A role informed by the responsibilities of traditional konohiki, resource managers, could be reoccupied by science teachers guided by Indigenous values of kuleana, responsibility, and mālama i ka ‘āina, care for the land that feeds.

Sabra Kauka enacts this role in active stewardship of Nualolo Kai and in her culturally grounded vision and commitment:

The survival of life on earth, let alone Hawaiian culture, depends on understanding how the natural world works. We get people from all over the world at Nualolo Kai. I tell them start where you are. We have to heed the teachings of our ancestors and mālama, take care of the earth. If we do it will take care of us and future generations. If we don't it will be the end of us.

Teachers who connect science learning to real issues in their students’ lives and places realize the need to develop personal expertise about local resources, issues, and Hawaiian landscapes. Many embrace the responsibility to teach and to learn when they find that developing local expertise and culture-science networks is professionally empowering. They seek knowledge and tools to engage their students in active learning supporting resilience and sustainability in a
complex, changing world. These indications of teacher agency are aligned with the OECD (2010) position that:

Non-formal and informal learning – learning that takes place outside formal education institutions – can be a rich source of human capital. Recognition of non-formal and informal learning makes this human capital more visible and more valuable to society at large (p. 1).

Conclusion

Western scientists and policy makers recognize that Indigenous approaches can play an important role in adaptive resource management and sustainability science. The saying “‘A ‘ohe pau ka ‘ike i ka hālau ho‘okahi, All knowledge is not taught in the same school” (No. 203: Pukui, 1983) reflects the diversity of knowledge that developed from living sustainably on Hawai‘i’s diverse islands with different geological ages, soils, terrain, microclimates, terrestrial and coastal ecosystems.

The community members who included Mālama I Ka ‘Āina, Sustainability in the first set of Hawai‘i State Science Content Standards recognized that Indigenous inquiry supports problem solving, systems thinking, and civic engagement oriented to sustainability. This Indigenous Hawaiian content standard foreshadowed the National Research Council’s call for a “research framework that integrates global and local perspectives to shape a ‘place-based’ understanding of the interactions between environment and society” (p. 10, 1999). I am among science educators in Hawai‘i calling for reinstatement of an Indigenous sustainability science standard inclusive of formal, non-formal, and informal knowledge.
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