Kahua A'o—A Learning Foundation: Using Hawaiian Language Newspaper Articles for Earth Science Professional Development

Pauline W. U. Chinn,[1,a] Steven Businger,[2] Kelly Lance,[2] Jason K. Ellinwood,[1] J. Kapōmaika'i Stone,[3] Lindsey Spencer,[1] Floyd W. McCoy,[4] M. Puakea Nogelmeier,[3] and Scott K. Rowland[2]

ABSTRACT

Kahua A'o, a National Science Foundation Opportunities for Enhancing Diversity in the Geosciences project, seeks to prepare educators to address issues of underrepresentation of Native Hawaiian students in Earth and Space Science (ESS) and science, technology, engineering, and mathematics (STEM) fields. An interdisciplinary team provides culturally grounded, place and standards-based curricula, and professional development (PD), drawing on 4,000-plus weather- and geology-related, Hawaiian-language newspaper articles that convey the importance of ecological knowledge to identity, social status, and sustainability. The project expands Hawaiian resources for science educators and scientists, supports revitalization of an endangered language, and presents original research correlating articles on drought and rains with 19th century El Niño–Southern Oscillation (ENSO) events. Professional development with two cohorts of educators finds interest in studying local phenomena, using technology to map cultural and science phenomena, incorporating place and culture into instruction, and, in some schools, challenges to implementing interdisciplinary instruction. [DOI: 10.5408/13-019.1]

Key words: Indigenous knowledge, place- and culture-based STEM education, professional development, Hawaiian language newspapers

INTRODUCTION

Ua lehulehu a manomano ka 'ikena a ka Hawai'i. Great and numerous is the knowledge of the Hawaiians (Pukui, 1983: No. 2814, p. 309). The Hawaiian Islands are highly vulnerable to natural hazards, including earthquakes, tsunami, hurricanes, and global climate change leading to drought, rising sea levels, ocean acidification, and threats to terrestrial and coastal ecosystems. Once sustaining a population approaching 1 million, at the time of European contact in AD 1778 (La Croix, 2002), Hawai'i is now the least sustainable state in the U.S., importing 85% of its food (Agroforestry.net, n.d.) and 90% of its energy (Spencer and Goodman, 2009). Native Hawaiians who could contribute cultural and historical knowledge to issues of sustainability and environmental literacy are underrepresented in Environmental Studies and Sustainability (ESS) majors, professions, and education. To bridge the culture–school science gap, *Kahua A'o*, a National Science Foundation (NSF) Opportunities for Enhancing Diversity in the Geosciences project, uses Hawaiian-language newspaper articles written between 1834 and 1948 as a foundation for culturally responsive, place-based earth science curricula, professional development, and research.

The Kahua A'o project's goal is to prepare middle-school science teachers with an earth science (ES) curriculum supporting Native Hawaiian students' entry into secondary and postsecondary science courses and majors. Its objectives are to (1) provide culturally responsive professional development, (2) develop and disseminate culturally grounded geosciences curricular materials, and (3) establish a community of research scientists, Hawaiian scholars, and science educators focused on science, technology, engineering, and mathematics (STEM) education. This article positions learning as culturally grounded, presents an overview of pre-Western contact Hawaiian culture, describes curriculum development, reports on professional development with two cohorts of educators, and concludes with implications for research and education.

LITERATURE REVIEW

Policy documents emphasize the sociocultural contexts of science learning. The U.S. Science Education Standards (National Research Council, 1996) expect teachers to "select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students" (p. 30). The National Science Teachers Association's (NSTA) 2000 Position Statement on Multicultural Science Education states: "Curricular content must incorporate the contributions of many cultures to our knowledge of science" and "science teachers are knowledgeable about and use culturally-related ways of learning and instructional practices." As the body that accredits science teacher certification programs, this is a mandate to develop science teachers' pedagogical content knowledge (PCK), defined by Shulman (1986) as a teacher's ability to

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[1]College of Education, University of Hawai'i at Mānoa, 1776 University Avenue, Honolulu, Hawai'i 96822, USA
[2]School of Ocean and Earth Science and Technology, University of Hawai'i at Mānoa, 1680 East West Road, POST 802, Honolulu, Hawai'i 96822, USA
[3]Hawai'inuiākea School of Hawaiian Knowledge, University of Hawai'i at Mānoa, Kawaiheulani Center for Hawaiian Language, 2540 Maile Way, Honolulu, Hawai'i 96822, USA
[4]University of Hawai'i–Windward Community College, 45–720 Kea'ahala Road, Kāne'ohe, Hawai'i 96744, USA
[a]Author to whom correspondence should be addressed. Electronic mail: chinn@hawaii.edu. Tel.: 808-956-4411. Fax: 808-956-9905

present content knowledge comprehensibly to specific students. The National Research Council's (2012) *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* grounds science learning in culture: "All science learning can be understood as a cultural accomplishment" (p. 283).

> *Particular cultural groups frequently develop systematic knowledge of the natural world through their members' participation in informal learning experiences, which are influenced by the groups' history and values and the demands of specific settings...that should be recognized in designing science learning experiences.* (p. 287)

Indigenous science educators Abbott (1992), Kawageley (2001), Crazy Bull (2010) and Price (2010) noted the importance of long-term, experiential, place-based knowledge in respective cultures. Each integrates cultural knowledge with western science and technology: Abbott (1992), Hawaiian ethnobotany; Kawageley (2001), Yup'ik technologies; Crazy Bull (2010), place-based environmental science; Price (2010), indigenous mapping. Price (2010) describes how Leech Lake Tribal College students use Landsat-7 images to map culturally important wild rice beds and noted that water fluctuations associated with climate change also affect Arctic and Pacific peoples with subsistence lifestyles.

Kates and Parris (2003) emphasize the roles teachers and education play in developing local capacity for place-based sustainable science by "identify[ing] the specific trends most relevant to such places and the ways in which local populations can contribute to altering the trends that affect them" (p. 8066). A recent survey of 17 nations, however, finds Americans least sustainable and feeling least guilty about their behavior (Than, 2012). This finding suggests cultural dissonance with national Earth Science Standard 3C: "Sustainability ... requires responsible management of natural resources not only to reduce existing adverse impacts but also to prevent such impacts . . ." (NRC, 2012, p. 195) and Hawai'i's former State Science Standard *Mālama I Ka 'Āina* [Care for the Land], Sustainability. The removal of the only Hawaiian standard to acknowledge culture exemplifies the dissonance between a culture oriented to sustainability and a national culture oriented to global competition. The Greenfield-Arambula (2005) review of multicultural science education literature led her to conclude that science teachers' views of science as objective, universal, and impersonal interfered with a recognition of cultural factors in teaching.

Current science education policy is aligned with Vygotskian views of learning as meaning-making involving communication. The Bruner (2006) view that "science-making is narrative" is seen in his recommendation that "instruction in science from the start to the finish . . . be mindful of the lively processes of science making" (p. 157). This generative, context-rich, learner-centered view of learning underlies the Loucks-Horsley et al. (2003) recommendation that providers of science PD "identify local needs based on analysis of student and other data" (p. 120) and the Lave and Wenger (1991) view of learning in communities of practice. These sociocultural views of learning guided the project's focus on in-service teachers established in schools, familiar with local needs, and interested in place-based learning bridging classroom and community.

Earth Science Literacy in Hawai'i

The first Polynesians arrived in Hawai'i around AD 1000, guided by navigators with knowledge of westerly winds, currents, birds, and stars (Finney et al., 1989). After long-distance voyaging ceased (Kane, 1998), the transmission of navigator knowledge lapsed in Hawai'i, although stories of culturally important figures, place names of departures and arrivals, even plants those figures brought continued in the oral literature. In 1976, Mau Piailug, a master navigator from Chuuk, guided the voyaging canoe *Hōkūle'a* from Hawai'i to Tahiti without instruments. This demonstration of indigenous knowledge and technology led to revitalization of voyaging, and in the context of the *Hōkūle'a's* departure on a worldwide voyage in 2014, renewed interest in Hawai'i's local and global winds.

A uniquely Hawaiian cultural complex (Kirch, 2010) integrated knowledge of society and environment to optimize agricultural and aquacultural practices, e.g., a lunar calendar prescribing ideal times for planting and fishing. Diverse topography, soils, and microclimates supported the development of knowledge-based, sustainable social ecosystems, called *ahupua'a* (Fig. 1), which typically extended from the mountaintop to the edge of the reef. Lower chiefs, *konohiki*, managed *ahupua'a* for sustainability through systematic monitoring linked to management of human behavior (Handy et al., 1991). Specialized, place-based knowledge developed in each *ahupua'a*. Where water was abundant, *konohiki* oversaw construction and maintenance of interconnected, stream-fed agriculture/aquaculture systems of *lo'i kalo*, irrigated taro fields and *loko i'a*, gated, rock-walled fish ponds stocked with herbivorous fish, e.g., *'ama'ama* (grey mullet, *Mugil cephalus*). People dwelling within an *ahupua'a* met most of their needs through a *mauka-makai* exchange of forest, upland products for lowland, coastal products. Abbott (1992) notes that Hawaiians located themselves in an *ahupua'a* the way people now locate themselves with street addresses and towns.

Hawaiian Newspapers as Repositories of Knowledge

Ecological information was transmitted orally in chants, stories, and sayings. Farmers and fishers used knowledge of weather to predict how changes in the wind might affect rains, fishing, and cultivation in their *ahupua'a*. A higher level of ecological knowledge was expected of composers and storytellers, who included named winds and rains from all the islands in their chants and epic tales. The shift from oral to textual transmission of knowledge developed rapidly after New England missionaries arrived in 1820 and, at the King's request, began teaching reading and writing to the royal court. Offered land for a high school in 1823, the American Board of Commissioners of Foreign Missions established Lahainaluna High School on Maui in 1831 with 25 students. In 1834, the first Hawaiian-language newspaper, *Ka Lama Hawaii*,[5] printed by Lahainaluna students, began providing reading material. Missionaries and the Hawaiian government were the sole publishers until 1861 when *Ka Nupepa Kuokoa* and *Ka Hoku o ka Pakipika*, the latter edited by the future King David Kalākaua (Chapin, 1996;

[5]Modern Hawaiian spelling includes diacritical marks, such as the '*okina* in "Hawai'i," but Hawaiian language newspapers did not use these marks, so we write their names without them.

FIGURE 1: Pre-Western contact *ahupua'a*. Source: Board of Water Supply, City and County of Honolulu, HI.

Brislin, n.d.), began providing a highly literate citizenry with a voice in the political arena (Nogelmeier, 2010).

Unlike Western newspapers that convey current events with books or journals that convey scholarly work, Hawaiian-language newspapers were the center of both current affairs and academic discourse, a conscious effort to preserve oral traditions and conserve knowledge as disease and cultural change rapidly reduced the numbers of experts holding traditional knowledge.

The detailed ecological knowledge recorded in Hawaiian newspaper articles reveals the importance of keen observation in Hawaiian culture. Readers shared specific bodies of knowledge, such as the names of the winds of a certain *ahupua'a* or the techniques of making twine from native plants, such as *olonā*. Scholars contributed epics of Hawaiian literature, such as that of Pele, the volcano goddess, who names the hundreds of winds of Kaua'i to prove that she is not a stranger to the island. Pele is well known in legend to reside in Halema'uma'u on the island of Hawai'i; thus, her comprehensive knowledge of winds of another island indicates the association of high status and identity as native born, *kama'āina*, on demonstrations of detailed, place-based knowledge. In another epic—the Wind Gourd of La'amaomao—a young man chants the hundreds of wind names associated with each of the Hawaiian Islands (Fig. 2). Lengthy answers to riddles (Maly, 2001) and recitations of winds served as indigenous maps, recording, naming, and locating winds, rains, and dozens of environmental zones in specific locales. Newspapers enabled readers to respond to the writings of scholars, leading to academic discourse full of additions, challenges, and disagreements.

After the 1893 overthrow of the Hawaiian Kingdom, a 1896 law forbidding Hawaiian as the language of instruction in all schools ensured the decline of oral and written Hawaiian. The last Hawaiian-language newspaper, *Ka Hoku o Hawaii*, ceased publication in 1948, but during the 114 years, an estimated 125,000 pages written by native speakers created a massive repository of Hawaiian text (Nogelmeier, 2010). Hawaiian newspapers entered science when Doak Cox, a Hawai'i-born geoscientist at the University of Hawai'i at Mānoa realized articles could expand historic records on earth science events (Lao and Miller, 2004). A subsequent collaboration between the Hawai'inuiākea School of Hawaiian Knowledge and the School of Ocean and Earth Science and Technology's (SOEST) Joint Institute for Marine and Atmospheric Research produced a digital database of more than 4,000 articles related to meteorology and geology (*Ke Au Hou*, 2012). These extend the information on earth science phenomena into precontact times, conserve Hawaiian words and ways of expression that might have been lost, and record cultural practices before and after Western contact.

PROJECT DESIGN

The Hawaiian newspaper database entered science education in 2011 through *Kahua A'o*—A Learning Foundation, an NSF Opportunities for Enhancing Diversity in the Geosciences award involving four units of the University of Hawai'i: *Hawai'inuiākea* School of Hawaiian Knowledge (M.P.N., J.K.S., J.K.E.); College of Education (P.W.U.C.), Windward Community College (F.W.M.), and SOEST (S.B., S.K.R., Sara Da Silva, L.S., K.L.). The team's different domains of expertise required co-teaching and cowriting to develop climate science and geology lessons aligned with state and national ESS standards that communicate a multiscience perspective (Harding, 2003).

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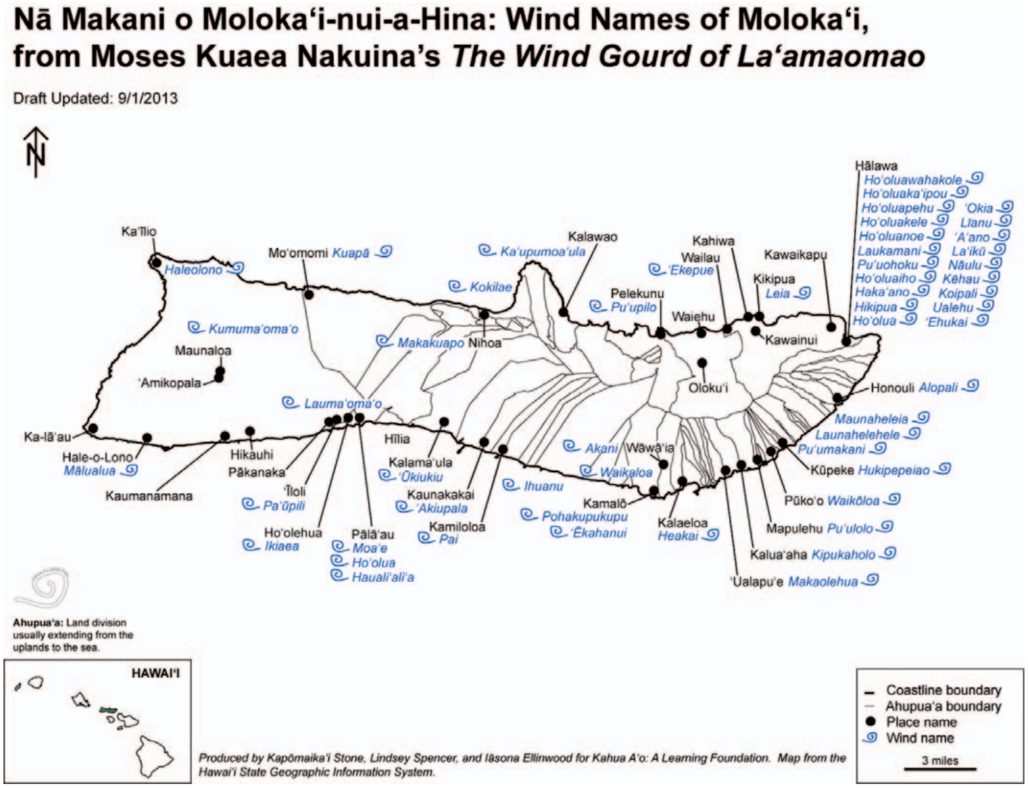

FIGURE 2: Wind map of Molokaʻi prepared by J.K.S., L.S., and J.K.E., Kahua Aʻo.

Hawaiian articles, as originally printed, translated, and selectively narrated in Hawaiian by J.K.S. and J.K.E. convey cultural views as well as keen observations and mindfulness of natural phenomena. Any language holds unique concepts and perspectives embedded within the words themselves. Pukui and Elbert (1986) use the Hawaiian word "*akeakamai*," translated as a "lover of wisdom" or "seeker of knowledge," for "science" or "scientist." A goal of the project is to arouse the *akeakamai* in teachers and students, with the recognition that all with *ake*, the desire to know, can be scientists. A proverb revealing how the lunar calendar is constructed with observations of natural phenomena illustrates a Hawaiian way of knowing what is called "science" in English. "*Welo huelo kū*—The standing tails sway," describes young vines appearing in the lunar month of Welo (around May), which may be pounced on by owls mistaking the shoots for rat tails (Pukui, 1983: No. 2935).

Kahua Aʻo lessons begin with a Hawaiian cultural guideline from *Nā Honua Mauli Ola*, Guidelines for Educators, *No Nā Kumu*: "Educators are able to sustain respect for the integrity of one's own cultural knowledge and provide meaningful opportunities to make new connections among other knowledge systems" (Native Hawaiian Education Council, 2002, p. 37). National and state science standards and benchmarks and a "To the Teacher" section, which provides both earth science and Hawaiian knowledge, connect knowledge systems through three objectives: (1) enabling ESS teachers to situate science content and standards in Hawaiian contexts and places; (2) familiarizing ESS teachers with science embedded in traditional stories, sayings, and practices; and (3) providing cultural resources to explore ESS phenomena in their own places. Lessons, audio files of Hawaiian language readings of selected articles, additional resources, wind maps, and photo galleries of project activities are posted on the project Web site http://manoa.hawaii.edu/kahuaao.

Professional development incorporates experiential learning and field trips to encourage teachers to become knowledgeable about their local weather or geology. Classroom and field-based inquiry activities and assessments include content presented in original Hawaiian-language newspaper articles and English translations. Hawaiian-language resources and visits to culturally significant sites are selected to be meaningful to Native Hawaiian teachers and students.

METHOD: CASE STUDY

Participants

Kahua Aʻo meteorology and geology lessons were piloted with two cohorts of educators in statewide Native Hawaiian Education Program (NHEP) projects. Cohort 1 was composed of 12 secondary public, charter, and private school science teachers in "All Together Now," a project to develop middle school science curriculum connecting the Polynesian Voyaging Society's (PVS) 2014–2016 World Wide Voyage and the Bishop Museum, a partner since the 1976 voyage to Tahiti. The more diverse Cohort 2 was composed of educators enrolled in or co-teaching an interdisciplinary science curriculum class with the first author. The 26 K–12 public and private school science, Hawaiian language and Hawaiian Studies teachers; informal science educators; a counselor; and administrator were part of "*Kūlia I Ka Nuʻu*, Strive for the Highest," an NHEP project. Table I shows the demographics of the PVS/Bishop Museum and Kūlia cohorts by gender, ethnicity, content focus, language of instruction,

TABLE I: Demographics and roles of educators in Cohorts 1 and 2.

Location	M	F	Language of Science Teacher	Informal Science Teacher	Hawaiian Language Hawaiian Studies	Administrator Counselor	Native Hawaiian	White	Japanese	Filipino
Kūlia	7	19	13 English	5	2 Hawaiian studies	2	9	10	4	3
			2 Hawaiian		2 Hawaiian language					
PVS	5	7	10 English	0	0	0	5	4	2	1
			2 Hawaiian							
Total	12	26	27	5	4	2	14	14	6	4

PVS = Polynesian Voyaging Society.

and instructional status, e.g., classroom teacher, informal educator, administrator. Hawaiian language immersion science teachers were present in both cohorts.

Professional Development

Kahua Aʻo provided curriculum and PD aligned with the goals of both NHEP projects that task teachers with developing culturally responsive, place-based science curricula. Meteorology lessons were piloted with the smaller PVS/Bishop Museum cohort because of its focus on Polynesian voyaging. Meteorology and geology lessons were piloted with the larger, more-diverse Kūlia cohort. Nine lessons have been taught; lessons on El Niño and La Niña in Hawaiʻi, hydrology, and waves and currents will be taught in 2014.

1. Hadley Cell and the Trade Winds of Hawaiʻi: *Nā Makani Mau*
2. Local Winds and Rains of Hawaiʻi: *I Kamaʻāina i nā Makani a me nā Ua*
3. Weather Maps and Hazardous Storms in Hawaiʻi: *Nā ʻIno ma Hawaiʻi Nei*
4. Atmospheric Pollution and Global Warming: *Pohina i ka Uahi*; National Weather Service Honolulu Forecast Office, University of Hawaiʻi-Mānoa
5. Plate Tectonics and Hawaiian Rocks: *No nā Pōhaku*
6. Geology of Hawaiʻi, Southeast Oʻahu Field Trip
7. Geology of Windward Oʻahu: *He Huakaʻi i Koʻolaupoko*
8. Earthquakes and Tsunami: *No ke Ōlaʻi a me ke Kai Hoʻēʻe*
9. Geology and Meteorology of Hanauma *Bay: He Huakaʻi i Hanauma*
10. El Niño and La Niña in Hawaiʻi: *Uē o Kanepūniu i ka Wela o ka Lā*

Field notes, participants' written evaluations, and reflections by the Kahua Aʻo team are data sources for examining the adoption of Kahua Aʻo curricula and outcomes by those participating in the project.

FINDINGS

Field Notes

PVS/Bishop Museum Cohort 1

Meteorology lessons 1–3 were piloted at the Bishop Museum with Cohort 1 teachers because topics aligned with the theme of Polynesian Voyaging. Lessons 1 and 3 were classroom-based, but for Lesson 2 Local Winds and Rains of Hawaiʻi: *I Kamaʻāina i nā Makani a me nā Ua*, teachers went outdoors with anemometers to measure wind speeds on the Bishop Museum campus. Teachers knowledgeable about Hawaiian canoes suggested tying a strip of *kapa*, bark cloth or *lei hulu*, a feather lei, to a pole, analogous to those tied to canoe masts to indicate wind direction and speed to increase the cultural relevance of the lesson. A Hawaiian immersion science teacher adopted the lesson for her middle school students then developed it into her NHEP lesson. Teachers asked J.K.S. and J.K.E. to find articles on their local winds and rains and a Bishop Museum educator requested training for docents. At the training session, a question from the museum educator about locating the winds named in *The Wind Gourd of Laʻamaomao* (Nakuina, 2005) led J.K.S. to develop hand-drawn maps.

L.S., J.K.S., and J.K.E. then developed ArcGIS wind maps for each island, converting major elements into layers: coastlines, wind and place names, and *ahupuaʻa* boundaries. The maps showed that wind and place names conveyed ecological and cultural information. On the island of Hawaiʻi, Miloliʻi's Kuehukai wind, meaning "churned up sea spray," suggests interaction with coastal waves, whereas its place name Miloliʻi, "twisted sennit cord," could either honor an expert sennit twister or refer to a "small twisting," as a current (Pukui et al., 1974). The importance of local knowledge for understanding winds and wind names was also seen in a participant's answer to a question about the numerous winds in Molokaʻi's Hālawa Valley (Fig. 2). A Hawaiian immersion science teacher who grows taro in the valley said it was likely due to facing into the prevailing north–east trade winds: the deep valley and its many smaller side valleys would generate many unique, local winds. Museum science educators decided to adopt elements of the lesson for museum programs, and the educator who arranged the docent training enrolled in the interdisciplinary class described as Kūlia Cohort 2.

Kūlia Cohort 2

Cohort 2 began 6 months after Cohort 1. Although participants visited the Bishop Museum, seven Kahua Aʻo lessons (except for lessons 1 and 3) were delivered at the University of Hawaiʻi at Mānoa campus and at community sites during a 9-month period. One-third of educators co-enrolled as teams to integrate their programs and to codevelop lessons spanning courses, grades, and sites.

Delivery of Lesson 4—Atmospheric Pollution and Global Warming—at the university included a visit to the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS), where an approaching tropical storm was being tracked. A debriefing with the Director of Operations led to a discussion of Hawaiian-

FIGURE 3: Southeast O'ahu field trip, Koko rift zone. Photo by Scott K. Rowland.

language weather reports for possible inclusion in NWS reports. A Hawaiian-language teacher planned to use Hawaiian newspapers as a model for her students' weather reports after J.K.S. showed videos of Māori-language weather reports.

Delivery of Lesson 5—Plate Tectonics and Hawaiian Rocks: *No nā Pōhaku*—at a geology laboratory included displays of Hawaiian rocks and stone tools. Teachers appeared very engaged in identifying a stone or mineral they had brought and observing Scott Rowland shape a Hawaiian stone implement. The following day, the Southeast O'ahu Field Trip introduced teachers to culturally and geologically significant places associated with Pele's search for a volcanic hearth after her arrival from Tahiti. (Her search is associated with volcanic rejuvenation because she landed on preexisting islands.) A hike up Wa'ahila Ridge, adjacent to campus, oriented teachers to the Ko'olau and Wai'anae shield volcanoes and Honolulu rejuvenation series, which includes Pu'u 'Ualaka'a (Round Top), Lē'ahi (Diamond Head), and Pūowaina (National Memorial Cemetery of the Pacific). Teachers used topographic maps and the global positioning system (GPS) to locate themselves on the ridge, and they studied olivine crystals with hand lenses. A stop at Kaimukī [the ti oven], provided views of other rejuvenation events, whereas the stop at Kawaiku'i Beach Park revealed a spring that is visible at low tide. The name of the spring and beach park, Ka-wai-ku'i [united water], captures the mingling of fresh and salt water. The road to Hanauma Bay passed over the wall and gates of Kuapā Pond, once Hawai'i's largest fishpond. Figure 3 shows a section of the fishpond and four vents of the 40,000- to 50,000-year-old Koko Rift with Hanauma Bay at the bottom and the Mānana Island at the top of photograph. The stop at Makapu'u [bulging eyes], named after a supernatural woman in an epic tale, offered olivine crystals and views of three rejuvenation events, the Kaupō flow emerging from the flanks of the Ko'olau shield volcano, and two small islands: Mānana, a tuff cone, and Moku Hope, a scoria cone (top of Fig. 3). The geology field trip ended at Hanauma Bay, meaning curved or arm-wrestling, a nature preserve, with a close study of a tuff cone.

Geology field trips familiarized teachers with ES content, tools, and technologies in the context of familiar, accessible, culturally significant sites in the most populated districts on O'ahu. All lessons provided models for integrating earth science, culture, and inquiry and communicating in diverse ways, e.g., J.K.S.'s Hawaiian-language weather report employing traditional place names; names for the sun, winds, and rains; and moon-related farming and fishing traditions. Teachers' use of anemometers, GPS, and wind maps led to interest in measuring and mapping winds, plants, and cultural sites in their communities. J.K.S. and J.K.E. helped teachers adopt lessons by finding and translating Hawaiian articles related to their places and programs. Two teachers developed and shared lessons using Web-based mapping technologies; teachers requested and participated in two mapping workshops.

L.S. began teaching a participant's high school Polynesian Voyaging students to use ArcGIS (ESRI, Redlands, CA) to create maps of their community to share during Hōkūle'a's World Wide Voyage. She and students later peer-taught an integrated lesson at Kawaiku'i Beach Park to 120 fourth-grade students from a nearby school. Children visited the spring bubbling through the sand, learned how to use anemometers to measure wind speeds, then made and flew kites, a traditional activity revealed in the name of that place, *Wailupe*, kite water.

Written Evaluations

Teacher feedback falls into 3 broad categories: (1) standards and school policies; (2) contexts of place, culture, and language; and (3) connecting learning to prior and personal experiences.

1. Standards and school policies: The middle school team co-enrolled to learn to integrate culture and science as a response to school polices that prescribed specific grade-level content. After the lesson on Plate Tectonics and Hawaiian Rocks one wrote: "Sorry, I have 6th grade and we do physical science. I enjoy geology and wish I could teach some of it." She could teach elements of the Atmospheric Pollution and Global Warming lesson when "we connect it to sustainability. I think visiting NOAA and listening to Steven [Businger] was very interesting. There's much for students to learn about pollution." Another noted that winds and rains were "relevant to 4th quarter ecosystem and water cycle," when students studied "specific environments," such as "alpine, rainforest, ocean/seashore." It was "not really my content area but I like learning about this kind of information."
2. Contexts of place, culture, and language: Responses to the question "What about the lesson would engage your students' interest and curiosity" are summed up in the quote: "That it is place-based would engage my students' interest and curiosity." Teachers considered activities with field maps and handheld GPS units to be appropriate for middle and high school students. Teachers in both cohorts found the lesson Local Winds and Rains of Hawai'i a good model for studying local weather and wind and rain names. A teacher recommended inclusion of more cultural content in geology lessons:
   - *[Students would find] formation stories engaging because this would relate to some students' cultures. Also, because the students often go to coastal areas, they might be interested in why certain areas look the way they do… .I liked when Pele was being talked about as we went over island ages, then went into detail. I think if there were more stories [the lesson] would be stronger*.
   - The lesson "Atmospheric Pollution and Global Warming," the visit to the NWS, and the Māori language weather reports provided a model for a Hawaiian-language teacher who planned to use the Hawaiian newspaper database to study Hawaiian terms and how people expressed what they saw: "My students could then create their own observations, in Hawaiian, on today's climate and current conditions" using the communication styles and terminology of native speakers of Hawaiian. She "enjoyed learning about Vog" [volcanic smog and fog], considering it a starting point for a collaboration with her natural resources science colleague. Hawaiian newspapers would be sources of data on how VOG affected plants and people, leading to conditions needing treatment.
3. Connections to personal experiences and prior knowledge: Teacher pretests on "Local Winds and Rains of Hawai'i" showed clear superiority of teachers participating in the Polynesian Voyaging Society crew training. Even if not science teachers, they showed higher content knowledge than did science teachers lacking those informal learning experiences. Teachers found lessons meaningful when connected to personal interests and experiences. A teacher found learning about olivine meaningful because "my boyfriend noticed and asked about it but I didn't know the answer … but now I do." A teacher liked the assignment to bring a rock or mineral because it would involve students with objects they would "encounter on their own adventures" and "they are things I can see so it makes it real for me." She appreciated S.K.R.'s analogy of making Hawaiian tools by flaking, to propagation of a crack in a windshield because students would connect their informal learning to culture and physics.

Perspectives of Kahua A'o Team

The team found transdisciplinary curriculum development to be a creative, deeply insightful process requiring co-learning and co-teaching. Team and teacher feedback informed the cycle of curriculum development, revision, and inspired innovations, e.g., ArcGIS wind maps, ArcGIS workshops, and Hawaiian-language weather reports. J.K.S. reflected on being a member in an interdisciplinary community of practice (Lave and Wenger 1991):

> *Working as a member of the Kahua A'o team … allows … boundaries that I have been taught about education to fall away. I now see that true education is an integrated education … I have found this through the lessons,*

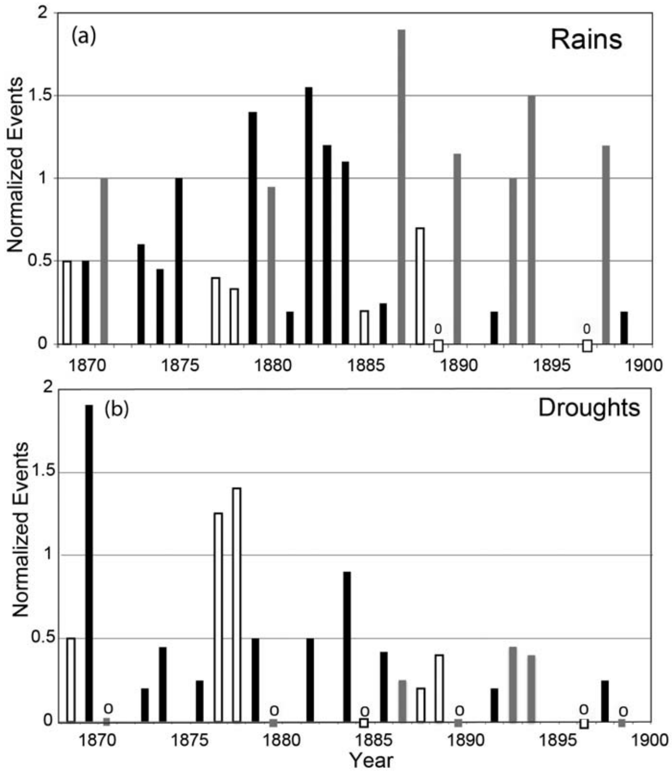

FIGURE 4: Histograms of the number of reports of (a) heavy rains, and (b) droughts, normalized by the number of issues published per month between 1870 and 1900. White = El Niño years; Gray = La Niña years, Black = ENSO neutral years. S.B. and K.L., Kahua A'o, 2013.

workshops, students, and fellow educators that we work with. I see that to inspire teachers and students about earth sciences, you must go out into your natural world, make observations, and interact with the earth. And then, when we are reminded, and shown stories of the past that explain our earth systems, there is a resonance in our beings. We remember the earth as our mother, the sun as our father, and our responsibility of stewardship with the land . . . Without a cultural and historical context to what we are learning, there is a disconnect. And it is hard to care, or learn about something you do not feel connected to. I see Kahua A'o as a . . . model bridging, translating, and rearticulating past and present knowledges to ensure the future has a holistic education pathway, where all students can learn and remember their connection to mother earth [our] ancestors stewarded so well.

The wind maps became a new tool for instruction and inquiry, serving as a foundation for J.K.S.'s Hawaiian-language weather report with traditional place, sun, wind, and rain names and farming and fishing practices appropriate to phases of the moon. Wind maps and weather report increased teacher interest in ArcGIS, GPS, anemometers, and other tools for ES inquiry. Collaborations with informal science educators led to integration of project curricula into Bishop Museum and Hanauma Bay Education Center (HBEC) programs. As an outcome of the southeast O'ahu field trip, Lesson 9 "Geology and Meteorology of Hanauma Bay: *He Huaka'i i Hanauma*," was developed in collaboration with HBEC and piloted with educators from Cohorts 1 and 2 and others responding to Hanauma Bay workshop announcements. The lesson will be co-posted on Kahua A'o and HBEC Web sites as an HBEC field trip. Finally, J.K.S.'s introduction of mapping led to co-learning by Kellie Kong, Kūlia's educational technology graduate assistant, collaborations with community experts, mapping workshops led by Kong, and P.W.U.C. and Kong's co-teaching of the College of Education's first mapping class in fall 2013.

Original Research

Lesson 10 "El Niño and La Niña in Hawai'i" contributes S.B. and K.L.'s original research on 19th century El Niño and La Niña events. References to droughts, floods, and heavy rains in the O'ahu newspaper *Ka Nupepa Kuokoa* from 1870 to 1900 were collected, and the results compared with a record of El Niño and La Niña events reconstructed using proxy data sets, e.g., tree rings and ice cores in areas sensitive to ENSO cycles (McGregor et al., 2010). Tallies of articles on droughts and floods in were normalized by the number of issues published per month to more accurately reflect differences in weather versus numbers of articles. For droughts, the normalized numbers were El Niño, 0.536, and La Niña, 0.157; for heavy rains, the normalized numbers were El Niño, 0.305, and La Niña 1.1 (Fig. 4). These results indicate more droughts and fewer heavy rains accompany El Niño events, whereas few droughts and more heavy rain events occur during La Niña years, consistent with 20th century records.

Limitations

The project's focus on Hawaiian language, knowledge, and place, and the pilot with two cohorts of educators in Native Hawaiian Education Programs do not allow us to generalize findings to other populations. However, the place- and culture-based PD approach may be transferable (Lincoln and Guba, 1985) to educators interested in sustainable practices, place-based inquiry, and cultural connections to place.

IMPLICATIONS FOR PRACTICE AND FUTURE DIRECTIONS

Preparing teachers to include culturally diverse content and instruction reflecting students' informal, place-based learning is an important task, given increasing student diversity and concerns over sustainability that require informed public engagement. Integrating place-based Hawaiian knowledge with place-based earth science establishes a shared foundation for further learning. Teachers recognize that systems-oriented, place-based Hawaiian knowledge contributes to meaningful, engaging, rigorous instruction but may be constrained by school policies that discourage content integration or lack of supplies, e.g., handheld anemometers, GPS units, and texts, e.g., *Wind Gourd of La'amaomao* (Nakuina, 2005), *Native Planters in Old Hawai'i* (Handy et al., 1991), *Place Names of Hawai'i* (Pukui et al., 1974), which are not typically found in science classrooms.

In the first 2 y of the project, the team actively supported teachers and presented six refereed posters and presentations. Participating in the project appears to convey the importance of education as a career. Though none of the five students hired were in education programs, J.K.S. and J.K.E. subsequently entered postbaccalaureate certification programs, Da Silva was hired as a science teacher after completing her master's degree in meteorology, and J.K.S. applied for a Hawaiian-language position. PD and outreach for 2014 will include lessons on El Niño and La Niña, hydrology, and currents and waves; posters at the American Geophysical Union/Ocean Sciences Meeting, presentations at the National Association for Research in Science Teaching and the American Association for the Advancement of Science annual meetings, a series of weekly lectures at Hanauma Bay in April, and publication of an article.

CONCLUSION

By interweaving traditional knowledge with science and technology, indigenous knowledge becomes more accessible, enabling Hawaiian perspectives and practices to contribute to 21st century STEM learning. The incorporation of Hawaiian newspaper articles in ESS curriculum highlights a nearly untouched resource for educators and scientists and increases awareness of the science underlying Hawaiian cultural practices. Because most of the 4,000+ weather- and geology-related articles remain in Hawaiian, inaccessible to most teachers, Kahua A'o supports equity in science education by providing all of Hawai'i's students, but especially those identifying themselves as Hawaiian, with "meaningful opportunities to make new connections among other knowledge systems" (NHEC, 2002, p. 37). The project provides data-rich, place-based cultural and STEM resources and encourages educators to be *akeakamai*, lovers of wisdom and seekers of knowledge, who recognize and teach the science within their students' cultures and communities.

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