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A Unique Marine and Environmental Science Program for High School Teachers in Hawai‘i: Professional Development, Teacher Confidence, and Lessons Learned

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Abstract: Hawai‘i is a unique and special place to conduct environmental science inquiry through place based learning and scientific investigation. Here, we describe and evaluate a unique professional development program for science teachers in Hawai‘i that integrates the traditional approach of providing training to improve content knowledge, with the overarching theme of scientific inquiry and investigation through short duration research experiences. Ten middle and high school teachers primarily from Hawai‘i public high schools participated in the four week, full time professional development course, producing novel place-based lesson plans to execute in their home classrooms. Pre and post analyses of teacher reported confidence levels in teaching ten environmental and marine science topics showed significant improvements after the course. In addition, teachers continued professional relationships with scientists and instructors of the program through synergistic activities including partnering in grant proposal submissions, participating in related university offered programs for K-12 audiences, and facilitating student research internships with university scientists. Despite the overwhelming positive evaluations by teachers of the value and efficacy of the program, lack of funding and access to equipment were reported as anticipated limitations to implementing their newly gained knowledge in the classroom. Nonetheless, the program’s success demonstrates that both teachers and scientists can benefit from a course of this nature, and using this framework, other organizations might adapt elements of the course to provide a similar place-based program in their respective back yards.

Keywords: evaluation, high school, marine biology, marine science, research experience for teachers

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Introduction

Science topics in education reform agendas have received much attention over the last two decades, promoting a need for greater emphasis on 'authentic scientific inquiry' experiences at the K-12 level (American Association for the Advancement of Science, 1993; National Research Council, 1996). The value of this approach has again been underscored in the National Research Council's (NRC) *A Framework for K-12 Science Standards: Practices, Crosscutting Concepts, and Core Ideas* (2012). In their recently released report, the NRC suggests that "engaging students in the full range of scientific practices helps students understand how knowledge develops, and gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world". Despite these repeated calls, much of the educational literature shows that opportunities available for students to engage in 'real' scientific experiences at school are often weak in terms of their 'authenticity' (Chinn & Hmelo-Silver, 2002; Hume & Coll, 2010; Lemke, 1992). Some researchers suggest these limitations stem from a variety of factors, such as those relating to classroom teachers having a simplified view of the practice of authentic scientific inquiry (Blanchard, Southerland, & Granger, 2009; Hume, 2009), teachers who are required to teach outside of their disciplines (Levin, 1985; Mervis, 2007), or educators that lack sufficient learning supports (e.g. professional development) to inform the design of their curricular programs (Beyer, Delgado, Davis, & Krajcik, 2009; Blanchard, et al., 2009). There also seems to be some amount of debate among science educators as to what the definition of 'authentic scientific inquiry' really is (Hume & Coll, 2010), disagreement as to the correct interpretation and execution of 'the scientific method' sometimes stemming from misperceptions related to descriptive versus investigative science, and the various ways authentic scientific investigations can be legitimately executed (Windschitl, Thompson, & Braaten, 2008).

While the NRC (1996, p 59) stressed the importance of teachers having "a strong, broad base of scientific knowledge extensive enough for them to understand the nature of scientific inquiry", relatively few opportunities exist for teachers to get real training in scientific investigation. To really understand and teach science inquiry effectively requires familiarity and/or training in the process of scientific inquiry and investigation itself (Westerlund, Garcia, & Koke, 2002). Teachers who have had professional development in this area have been shown to dedicate significantly more time to laboratory activities in their teaching (Boser & et al., 1988) and have reported that they "think differently" about how they approach the teaching of science to their students (Kielborn & Gilmer, 1999). The National Science Foundation (NSF) Research Experiences for Teachers (RET) program provides a means for teachers to work directly with scientists on research project investigation, and has shown much potential in bolstering inquiry based teacher learning supports (Blanchard, et al., 2009; Russell & Hancock, 2007).

In addition to the dearth of opportunities available for direct scientific investigation, the lack of teacher confidence has also been cited in numerous studies as a major impediment to teaching science inquiry, and that personal content knowledge impacts the perceived confidence of teachers (Garbett, 2003; Harlen, Holroyd, & Byrne, 1995; Kind, 2009; Murphy, Neil, & Beggs, 2007). Such measures of confidence are often expressed as a self-reported measure, determined using Likert-scale items either alone or in combination with open ended response survey questions. The results of these types of assessment instruments reveal that teachers' low confidence in teaching science subject matter stems from numerous factors, including inexperience, lack of expertise, and lack of competence (Garbett, 2003; Murphy, et al., 2007). Further, professional development has been noted as among the most important influences of improved confidence in science teaching (Murphy, et al., 2007).

Given the demonstrated value of scientific research experiences as a means of science teacher professional development and the value of professional development in bolstering confidence in teaching science, a logical approach to overcoming the apparent disparities between school-based and real-world science is to provide more opportunities for in-depth teacher training in investigative science that is developed and delivered by practicing research scientists. While the RET model has been demonstrated to be an effective means of accomplishing this goal, relatively few professional development opportunities are constructed such that teachers are exposed to a somewhat broader array of science content (as opposed to the more traditional, single subject intensive research ‘apprenticeship’), while still being delivered within overarching themes of the scientific method, inquiry, and investigation. Even fewer are likely delivered explicitly within a place-based environmental setting.

In this paper, we describe a marine and environmental science professional development summer program that used place-based settings located on the windward side of the island of O‘ahu, Hawai‘i, as taught by practicing research scientists and educators. We explain some of the main elements of the program’s content, some of the notable outcomes and opinions shared by our participating teachers, and offer insights of the program and teachers from our point of view primarily as scientific researchers and mentors. In addition, we describe changes in teacher reported confidence in teaching an array of environmental and marine biology topics within the overarching theme of scientific inquiry and investigation.

Program Features

Hawai‘i offers a unique and special place to conduct environmental science inquiry that allows for teachers to share with students the knowledge they develop through place based learning and scientific investigation. Our professional development course provided a month long inquiry focused and place-based marine and environmental science professional development course for Hawai‘i high school teachers. It was coordinated, developed and instructed by three university faculty members with primarily science research backgrounds in marine and environmental biology, but who also have considerable professional experience in curriculum development, teaching and mentoring at the K-20 levels. The course was delivered at the University of Hawai‘i’s (UH) Windward Community College (WCC) and UH Mānoa’s Hawai‘i Institute of Marine Biology (HIMB), whose instructional and research facilities are both situated on the windward side of the island of O‘ahu (within the Kāne‘ohe, He‘eia, and Kea‘ahala watersheds, see Figure 1). This area of the island is rich in outdoor opportunities to investigate natural processes within the context of environmental science and marine biology.

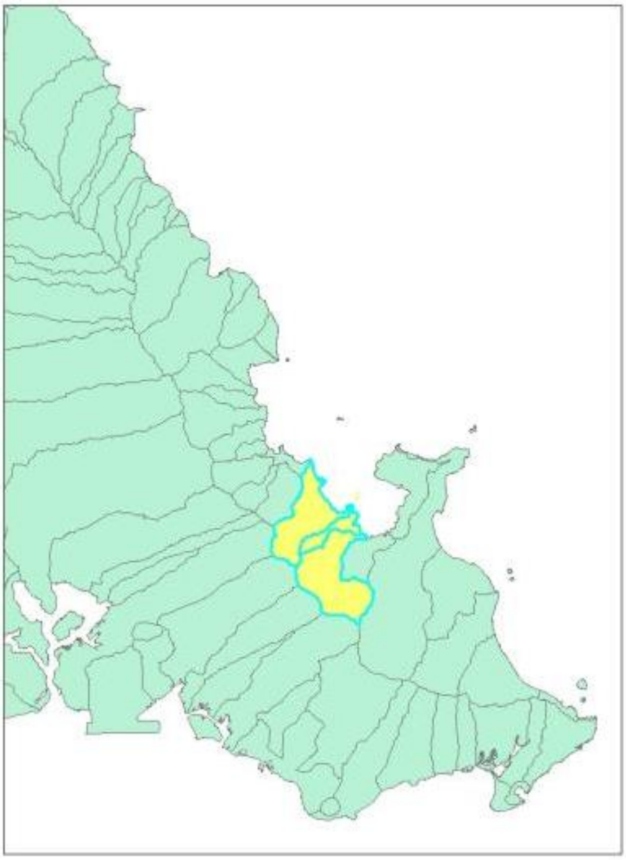

Figure 1. *Map showing the south east area of the island of O'ahu. The Kāne'ohe, He'eia, and Kea'ahala watersheds (highlighted in yellow) provided the contextual backdrop for the course*

The program we conducted was funded by a National Oceanic and Atmospheric Administration Bay-Watershed Education and Training grant to HIMB. The course occurred in June-July 2009 over a four week period during the summer break, and provided a total of six upper division UH credits through the College of Education's Curriculum Studies Department in (1) Interdisciplinary Science Curriculum and (2) Methods and Materials in Science. In addition, a modest stipend was provided to support teacher participation and help them pay for the costs of enrolment in the two courses. The instructors were marine biologists from HIMB and WCC, whose primary areas of expertise included coral biology, population genetics, and fish physiology. Classes were held at the WCC campus which has both classroom and laboratory facilities, and at the research institute of HIMB, as well as various outdoor field sites mainly on the windward side of O'ahu (Figure 1).

The program was entitled *Human Impacts and Hawai'i's Coral Reef Health: A Marine and Environmental Science Program for High School Teachers in Hawai'i*. The course was developed within the contextual framework of watershed processes and their connection to nearshore coastal marine resources in windward area watersheds. The Hawaiian concept of *ahupua'a,* a traditional land management and political land division in ancient Hawaiian culture, was emphasized throughout the program. The *ahupua'a* is similar in function to the 'watershed', yet differs geographically in that its boarders extend into the sea, emphasizing the land-sea continuum. In this paper, the term 'watershed' and the Hawaiian term 'ahupua'a' are used interchangeably[1].

Course content was organized into four broad science themes: abiotic factors, ecological factors, coral reef biology, and microbiology. Each theme area was taught for approximately one week, totalling over 133 contact hours over the four-week period. Specific science topics and daily activities within each theme are detailed in Table 1. Topics were introduced with lectures by HIMB scientists or other guest lecturers with the appropriate science backgrounds, and were followed by related in-depth and hands-on inquiry activities either in the lab or in the field. Service learning projects were interspersed throughout each module to provide an environmental stewardship component to the overall program. In addition to the specific science content areas, concepts such as the nature of science, the scientific process, and human impacts to the environment were emphasized as cross cutting themes.

Teachers worked as research teams in pairs or in groups of three to four individuals for lab and field exercises each day. The last day of each week was dedicated to lesson development, where teachers created new activities for their home classrooms based on

Table 1. *Specific science topics covered within each weekly theme via lectures, labs, field surveys and stewardship service projects*

Week	*Lectures*	*Hands-on lab and field activities*
	Abiotic Factors	
	Watersheds and watershed mapping	Kāne‘ohe watershed tour Using environmeters and barometers
	Climate and hydrology	Waihe‘e[1] water supply tunnel fieldtrip
	Properties of water	Properties of water lab
1	Formation and characterization of soils	Soils lab
	Water quality	Field water quality data collection and analyses
	The nature of science and the scientific method	Lesson planning and collaboration session
	Ecological Factors	
	Population and community ecology	Population ecology lab
	Estuaries	Kahe[2] estuary dynamics survey
2	Life in Hawaiian streams	Stream bioassessment survey
	Hawaiian intertidal zone	Intertidal zone survey Seaweed pressing lab
		Lesson planning and collaboration session
	Coral Reef Biology	
	Coral reefs and human impacts	Reef species identification lab Coral reef survey techniques Collecting microbes
3		Plate streaking and sterile techniques
	History of Kāne‘ohe Bay	Taro patch service work fieldtrip Coral reef surveys in Kāne‘ohe Bay
	Kāne‘ohe Bay master planning	Lesson planning and collaboration session
	Environmental Microbiology	
	Environmental microbiology	Microbiology lab
	Molecular genetics	DNA extraction
	Principles of PCR[3]	PCR lab
4	Hawaiian fishponds	Waikalua Loko fishpond service work fieldtrip
	DNA sequencing and BLAST[4]	BLAST lab
		Lesson planning and collaboration session

1. Waihe‘e is an area in windward O‘ahu that is an abundant and natural municipal freshwater source.
2. Kahe is an estuary area in east O‘ahu.
3. PCR = Polymerase Chain Reaction, a technique used commonly in molecular biology.
4. BLAST = Basic Local Alignment Search Tool- a DNA sequence database that searches for sequence similarities.

Table 2. *Lab report topics required of participants*

Week	Lab Report	Theme
1	Properties of water Soils Water quality	Abiotic Factors
2	Estuaries Stream bioassessment Intertidal survey	Ecological Factors
3	Coral reef survey	Coral Reef Biology
4	DNA, PCR and BLAST	Environmental Microbiology

the new content they learned during hands on field and lab experiences.

Successful completion of the course resulted in six upper division college credits with grades assigned. Grading was based on the successful creation of four scientific inquiry based lesson plans relating to the four themes. These lesson development assignments were required to be aligned to Hawai‘i Content and Performance Standards III Science Benchmarks and counted toward 60% of the final grade. Eight lab reports (Table 2) counted for 20%, and participation made up the final 20% of the grade. Grades were determined on a non-curved scale. At the end of the course, a DVD of lecture powerpoints, course materials, images, participant and instructor contact information, and teacher developed lessons were provided to each participant to use for future instructional resources.

Methods

Participants

Science teachers were recruited in the Spring of 2009 through advertisements on Hawai‘i science teacher and environmental educator listservs, program staff contacts, and through a university hosted website. Teachers with relatively little teaching experience that were from Hawai‘i public high schools were primarily sought out, resulting in a total of ten recruits for the program (our maximum target). While we developed the program for high school teachers from Hawai‘i, we did admit two middle school teachers from Hawai‘i public schools and two high school teachers from mainland schools (in Pennsylvania). Of the ten teachers, seven teach at Hawai‘i public schools, one at a Hawai‘i public charter school, and two at mainland public schools. The program

Table 3. *Teacher participant characteristics and reported reasons for participating in the program (1 = Develop instructional expertise, 2 = Professional development, 3 = Obtain instructional content, 4 = Stipend incentive, 5 = Other)*

Teacher	Grades Taught	Degree Discipline	Highest Degree	Years Teaching Science	Reasons for Participating
1	10-12	Life Sciences	Doctorate	3-5	1, 2, 3
2	9-10, 12	Life Sciences Education	Master’s	0-2	1
3	7	Life Sciences	Master’s	0-2	1, 2, 3
4	11	Education	Master’s	3-5	2, 3, 5[1]
5	9, 11-12	Life Sciences Education	Master’s	10+	3
6	9-10	Life Science	Bachelor’s	0-2	1, 2, 3, 4, 5[2]
7	9-12	Education	Master’s	0-2	1, 2, 3
8	7	Life Sciences	Master’s	0-2	1, 2, 3, 4
9	10-12	Life Sciences	Bachelor’s	0-2	1, 2, 3, 4
10	10	Education	Bachelor’s	3-5	1, 3, 4

1. Graduate credits.
2. Explore Kāne‘ohe Bay and Coconut Island (where HIMB resides).

participants came with a wide variety of backgrounds in degree types, science training, and teaching experience (Table 3). Degrees ranged from a Bachelor's in Education to a Ph.D. in the Life Sciences, and teaching experience from less than one year to more than ten years. Most teachers had a Master's degree in life sciences, education, or combination of both disciplines, with relatively few years of teaching experience (Table 3).

At the start of the program, we provided teachers a questionnaire that asked them to select among five choices the primary reasons they were interested in participating in the program. These responses, along with the aforementioned teacher characteristics are also detailed in Table 3.

Program Content and Lesson Development

The program content of our month long summer course was developed to follow the path of water through the ahupuaʻa, a ridge-to-reef management approach that highlights the connection between land, sea and human activities, in an effort to foster understanding of the concept that we are an integral component of a balanced ecosystem. Each week was divided into overarching themes that allowed us to explore a diverse array of science concepts using inquiry and in-the field and lab experiments to complement content, highlight the nature of science, and emphasize human impacts on ecosystems (Table 1).

The first of the four themes focused on abiotic processes such as weather, climate and hydrology that shape Hawaiian watersheds and influence soil properties and water flow. A field trip to the top of the ahupuaʻa in the Koʻolau mountain range on the windward side of Oʻahu was a valuable outdoor experience used to show our participants how wind and rain bring water to the ahupuaʻa and thus initiate the hydrologic cycle. Water is important in shaping the various habitats within the watershed (Juvik, 1998; Sanderson, 1993) as it fills dikes and streams (Takasaki & Mink, 1981), and erodes volcanic rock into different types of soils to provide habitat and nutrients for plants to grow and life to thrive (Sherman & Ikawa, 1968; Vitousek et al., 1997). The laboratory exercise that accompanied the field trip included a comparison of soils taken from the top of the ahupuaʻa and further down near a stream to characterize differences in moisture content, particle size and composition. Scientific inquiry was embedded in the lab activity, as participants were required to hypothesize on soil differences based on location along the ahupuaʻa using their newly acquired knowledge concerning the process of Hawaiian watershed dynamics.

During the second week, we transitioned from abiotic factors to ecological factors that shape community structure along two important Hawaiian watershed habitats: streams and estuaries (Evenhuis & Fitzsimmons, 2007; Ford & Kinzie III, 1994). An intensive field lab used a combination of physical, chemical and biological assessments to determine how water quality and the health of stream habitats change by comparing stream sites upstream and downstream from urban and industrialized areas of the watershed. Scientific inquiry and the effects of human impacts were embedded into this activity as we discussed water quality parameters, how they are measured, and how they change in the presence of human impacts. Participants were asked to develop hypotheses on how different parameters like stream flow, pH, oxygen content and presence of invasive organisms would differ between the stream sites before we conducted the field lab. We also visited a nearby estuary and performed physical and chemical assessments in two different locations that varied in their distance to the ocean and asked participants to hypothesize on how water temperature and salinity would change with depth and distance from the ocean. This provided an excellent transition to our investigation of the adaptations of flora and fauna in intertidal habitats, where abiotic and biotic processes further collide to facilitate a unique habitat and community structure (Cox, Philippoff, Baumgartner, Zabin, & Smith, 2012). The Hawaiian intertidal habitat is small because it lacks a large tidal fluctuation (Cox, Baumgartner, Philippoff, & Boyle, 2010) but it is important culturally since most of the algae (*limu* in Hawaiian language) that provide a significant source of trace minerals in a traditional Hawaiian diet are collected there. It is also an important nursery habitat for reef fishes (Cox, Baumgartner, Philippoff, & Boyle, 2010) and invertebrates and contains organisms that are specifically adapted to exist in the fluctuating conditions of exposure and desiccation, salinity and oxygen changes, and well as predators that derive from both land (birds) and sea, and makes for an easily accessible and excellent natural laboratory to study community ecology (Cox, Philippoff, Baumgartner, Zabin, & Smith, 2012).

Our third theme, coral reef biology, led our participants into the ocean to learn about the basic biology and ecology of coral reef ecosystems. Teachers were given a thorough introduction to the coral reefs of Hawaiʻi, and of Kāneʻohe Bay in particular. Kāneʻohe Bay is unique in that it is the only mature barrier reef and lagoon system in the main Hawaiian Islands (Hunter & Evans, 1995). The bay receives substantial freshwater input from the surrounding ahupuaʻa and is under direct influence from land and sea based human activities (Hunter & Evans, 1995; Jokiel, Brown, Friedlander, Rodgers, & Smith, 2004; Jokiel, Hunter, Taguchi, & Watarai, 1993), yet boasts a fairly healthy, productive shallow reef habitat. Ecological survey skills and the biology and ecology of coral reefs were emphasized as we trained our participants to conduct coral diversity surveys on snorkel to understand and identify healthy vs. compromised coral reefs. This also allowed our participants to experience the technical and logistical aspects involved in coral reef research which we feel was an important experience as the reef is the most variable of field sample sites and really exemplified the nature of ecological field sampling. For the final snorkel survey in this section of the course, our participants collected water and coral mucus samples so that we could start the cultivation of environmental microbes in preparation for the final theme of environmental microbiology.

The fourth and final theme of environmental microbiology connected land and sea to human impacts using microbial and molecular biology to assess the role of human influence within the reef habitat in terms of the diversity and types of bacteria present. For example, certain types of fecal indicator bacteria characteristic of mammalian intestinal flora can determine possible sewage or agricultural runoff influences coastal streams and in the bay (Viau et al., 2011). Other types of bacteria that are considered pathogenic to corals could indicate disease and possible compromised habitat, identifiable with molecular and microbiological tools .(Goto & Yan, 2011). While we were aware that many of the microbial and molecular techniques introduced through this last theme would be beyond the resource capability of the schools from which the participants taught, we wanted to give them insight into the technology and utility of these techniques to address many interesting research questions.

During each of the four weeks, we set aside time to incorporate community service or service learning projects in an effort to broaden our participants scope of field trip possibilities they could arrange for their courses. All of these projects relate to the integral link between land and sea, and human influence and necessity on sustaining healthy habitats. Participants visited the Waiheʻe tunnel, an above ground aquifer, to learn how the board of water supply captures this natural resource and delivers it to our taps. They participated in restoration projects removing invasive plants at an historical Hawaiian fishpond as well as a *loʻi*, a Hawaiian taro field. These projects we felt further instilled a sense of place and an emphasis on the importance of environmental stewardship to maintain our natural resources.

At the end of each weekly theme, participants used the content we had exposed them to, as well as relevant student learning outcomes for their grades and schools, to develop lesson plans specifically for their classrooms. Because we had participants who taught different disciplines, grade levels, and at different schools, this time was set aside for them to explicitly focus on how to connect what they were learning in our program to how they were going to disseminate the information to their students. Once the lesson plans were complete, each

Table 4. *Analysis of pre- and post- program confidence levels in teaching environmental and marine science topics covered in the program*

	Pre-Program Average	**Standard Deviation**	**Post-Program Average**	**Standard Deviation**	**Difference**	**Significance**
Watershed processes	2.6	1.07	3.6	0.52	1.0	p=0.015*
Water quality and properties of water	2.5	1.18	3.8	0.42	1.3	p=0.018*
Ecology	3.2	0.79	3.7	0.48	0.5	p=0.052*
Estuaries	2.2	1.14	3.5	0.53	1.3	p=0.006*
Hawaiian streams	1.8	0.79	2.9	0.57	1.1	p=0.001*
Hawaiian intertidal	2.3	1.06	3.4	0.52	1.1	p=0.003*
Coral reefs	2.6	0.70	3.3	0.48	0.7	p=0.01*
Marine biology and taxonomy	2.7	0.82	3.2	0.63	0.5	p=0.052*
Environmental microbiology	1.8	0.42	2.8	0.63	1.0	p=0.001*
Genetics	2.3	0.67	2.9	1.06	0.6	p=0.048*
The scientific method	3.6	0.52	3.8	0.42	0.2	p=0.34
Overall	2.51	0.50	3.35	0.36	0.84	p<<0.00001*

Data were analyzed using a paired t-test (*significant outcomes) (1 = not comfortable, 2 = slightly comfortable, 3 = moderately comfortable, 4 = very comfortable).

group would share their ideas with the other participants and invite feedback. At the end of the course, we collected electronic copies of the lesson plans, along with all the materials and resources used throughout the program, and disseminated the content via DVD to each participant.

Pre and Post Evaluation of Teacher Confidence in Teaching Science Subjects

On the first day of the program, we administered a questionnaire that asked teachers to rank on a four-point scale (1 = not comfortable, 2 = slightly comfortable, 3 = moderately comfortable, 4 = very comfortable) how comfortable they felt teaching ten selected environmental and marine science content topics. We chose not to use a five-point scale because we felt that not adding a fifth 'mid-point' option would force the respondents to really think about their existing comfort levels rather than just choosing the neutral (mid-point) answer. The topics ranked fell within the four themes (Table 1) of the program: (1) watershed processes, (2) water quality and properties of water, (3) ecology, (4) estuaries, (5) Hawaiian streams, (6) Hawaiian intertidal, (7) coral reefs, (8) marine biology and taxonomy, (9) microbiology and (10) genetics. In addition to these content areas, we asked teachers to also rank their comfort levels with the concept of 'the scientific method'. These same rank-response questions were again administered at the conclusion of the program to ascertain how teachers' confidence in teaching these topics changed as a result of their participation in the program. The pre-post data comparisons were analysed for significance using paired t-tests (Table 4).

Post Evaluation of the Effectiveness of Instruction by Weekly Theme and Overall

In addition to the pre and post evaluation on comfort levels, teachers were asked to evaluate the effectiveness of the instructors for each of the weekly themes, as well as their intention of applying their newly gained knowledge in their classrooms in the future. For consistency, responses were again ranked on a four-point scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) and these data were analysed for average scores and standard deviations (Table 5). Teachers were also asked to evaluate the overall execution of the program, which included questions related to whether content had relevance to science standards, program effectiveness and the anticipated administrative support in implementing newly learned concepts and materials in their schools. The specific questions and results

Table 5. *Individual teacher reported pre and post confidence levels in teaching environmental and marine science topics covered in the program (1 = not comfortable, 2 = slightly comfortable, 3 = moderately comfortable, 4 = very comfortable).*

Teacher	Pre	Post	Field of study	Highest degree
1	2.36	3.09	Life Sciences	Doctorate
2	3.55	3.64	Life Sciences/Education	Master
3	2.00	3.64	Life Sciences	Master
4	1.91	3.09	Education	Master
5	2.64	3.68	Life Sciences/Education	Master
6	3.09	3.45	Natural Resources	Bachelor
7	2.64	2.73	Education	Master
8	2.09	3.55	Life Sciences	Master
9	2.36	3.73	Life Sciences	Bachelor
10	2.45	2.91	Education	Bachelor

are shown in Table 6.

Pre and Post Open Response Feedback

At the start of the program, teachers were also asked to provide a short written narrative in response to a question asking them to describe what they hoped to get out of the experience. After completion of the program, teachers were again given the opportunity to share in an open response format what they got out of the program as ascertained through questions relating to the subjects they liked the most and the least, which they thought were most useful, and which they wish they had more information on. They were also asked to describe what kind of support they anticipated needing in order to implement new materials in their schools. Finally they were asked to offer comments and recommendations for improvements of the program delivery. Specific survey questions and teachers' responses are shown in Appendices I and II.

Table 6. *Post-program evaluation of instructors and utility of weekly themes (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree).*

Week 1: Abiotic Factors	Average	Standard Deviation
Presenter(s) were knowledgeable about content.	3.8	0.42
Presenter(s) integrated hands-on application of the content.	3.8	0.42
Presenter(s) were engaging and interesting.	3.6	0.52
I will apply what I learned when teaching my students.	3.6	0.52
Week 2: Ecological Factors		
Presenter(s) were knowledgeable about content.	3.8	0.42
Presenter(s) integrated hands-on application of the content.	3.8	0.42
Presenter(s) were engaging and interesting.	3.7	0.48
I will apply what I learned when teaching my students.	3.6	0.52
Week 3: Coral Reef Biology		
Presenter(s) were knowledgeable about content.	3.8	0.42
Presenter(s) integrated hands-on application of the content.	3.8	0.42
Presenter(s) were engaging and interesting.	3.7	0.48
I will apply what I learned when teaching my students.	3.6	0.52
Week 4: Environmental Microbiology		
Presenter(s) were knowledgeable about content.	3.9	0.32
Presenter(s) integrated hands-on application of the content.	3.8	0.42
Presenter(s) were engaging and interesting.	3.7	0.50
I will apply what I learned when teaching my students.	3.0	0.67
OVERALL	**3.7**	**0.39**

Results

Teacher Developed Lesson Plans

The lesson plans developed by our teacher participants were completed at the end of each week and corresponded to three of the four weekly themes. Participants were given one day at the end of each week to develop lesson plans derived from content they had learned that week. Participants who taught similar subjects and grade levels often grouped together to develop their lessons. At the end of the day, each group would informally present their lesson plans and generally, a casual and informative discussion ensued that allowed for shared collaborative learning between all participants. While content we delivered to teachers was at the level of college coursework, the lessons they developed from this content were more typical of middle-high school levels by simplified methodology and smaller-scaled study systems. Our participants developed a total of 15 different lesson plans tailored to their respective grade levels and courses.

Abiotic Factors Lesson Plans

Lesson plans that were developed by participants for the first week combined scientific inquiry with a field trip to stream sites to observe the interaction of abiotic and biotic factors. They incorporated the use of some of the water quality equipment we taught them to use to measure oxygen, pH and temperature of the stream. The groups that developed these lesson plans were local teachers who had access to near-by streams and could easily take their students into the field. Participants who did not have access to stream sites instead developed a lesson plan that used scientific inquiry to investigate various images of nature scenes taken from different biomes, asking students to delineate abiotic and biotic factors and hypothesize how removing some of these factors would affect the ecosystem.

Ecological Factors Lesson Plans

Scientific inquiry was embedded into lesson plans developed for ecological factors and focused on content relevant to participant's grade level and course. For example, a lesson plan focusing on food webs took students on a field trip to the intertidal to perform surveys of the organisms living in this habitat. Students were instructed to build a food web based on the organisms found and the interactions observed in the field survey as a working hypothesis to be further investigated. Another lesson plan utilized common estuary plants subjected to varying concentrations of salt in the water and asked students to hypothesize how well the plants would grow in these different salinity regimes. In addition to this lab experiment, the lesson plan included a field trip to an estuary to observe the plants and animals that thrive there and consider the adaptations these organisms have developed to tolerate such variable changes in salinity.

Coral Reef Biology Lesson Plans

Most participants concluded that it is beyond their means to allow their students to snorkel to observe coral reefs, and as a result, lesson plans were developed around in class instruction on the biology and ecology of coral reef habitats and why they are important ecosystems. Activities that were designed around this content included building dioramas, choosing a coral reef organism and writing a research paper or giving a presentation on it, and investigating human impacts to coral reef habitats.

Environmental Microbiology Lesson Plans

This topic, while beneficial for our participants to have the exposure to, proved difficult for them to incorporate into a lesson plan because of the specific equipment and technical skills required to execute a lab or activity of this nature in their respective grade levels and courses. While many participants expressed interest in exposing their students to the topics presented during this week, lesson planning time that was allocated for this topic was devoted to completing and enhancing the lesson plans they had previously developed. We did engage in a constructive discussion about how to promote environmental microbiology in their courses, the barrier of equipment costs and technical training, and other logistical hindrances that would need to be considered.

Teacher Reported Interest in Participating in the Program

Most of the teachers selected a variety of reasons for wanting to participate in the program (Table 3). Nearly all indicated that they were interested in multiple goals -- developing instructional expertise, professional development, and obtaining instructional content. Not surprisingly, the one teacher that had more than ten years of teaching experience indicated only a single interest -- to obtain instructional content. Interestingly, one teacher with less than two years of experience indicated that he/she only had an interest in developing instructional expertise and nothing else. Four of the ten teachers indicated that the stipend also provided additional incentive for participating. Two teachers indicated 'other' additional reasons for participating, namely obtaining graduate level credits and exploring the Kāneʻohe Bay and Coconut Island (an islet in Kāneʻohe Bay where HIMB resides).

The open responses to the question in which teachers were asked to describe what they hoped to get out of the experience were varied. In general however, teachers responded that they wanted to improve their expertise and gain new materials and content for teaching science. *"I hope to gain materials and information that will help me better engage my students"* was one such typical statement. Several teachers also indicated a desire to integrate Hawaiʻi based content to their teaching of science, as well as improve stewardship values in their students, through comments like *"I want to learn more about Hawaiʻi's ecosystems and learn how to bring that knowledge into my classroom. I hope to give my students a chance to explore the environment that they live in and understand how special Hawaiʻi is"*. One teacher indicated a specific desire to get more students interested in marine science careers by stating *"I would like to become a great and innovative marine science teacher that gets kids interested in marine science fields after high school"*. Complete responses are shown in Appendix I.

Changes in Reported Teacher Confidence Levels in Teaching Science Subjects after Completing the Program

We sought to explore teacher confidence by assessing self-reported 'comfort levels' in teaching these ten marine and environmental science topics and the process of investigative inquiry through the scientific method. In our study we assessed "confidence" both before and after the course in order to uncover any reported improvements in teaching these particular science topics. Table 4 shows pre-program self-reported average teacher confidence levels among the ten science topics covered during the four week program. These results ranged from 1.8 (between 'not comfortable' to 'slightly comfortable') on the low end for the topics of Hawaiian streams and environmental microbiology (standard deviation, SD = 0.79 and 0.42, respectively) to around 'comfortable' (3.2, SD = 0.79) on the high end for the subject of ecology. Interestingly, the concept of the scientific method received the highest average ranking (3.6, SD = 0.52) among teachers. Variation among teachers as evidenced by standard deviations ranging from 0.42 in genetics to 1.18 in water quality and properties of water indicated that teachers in this cohort had a wide range of comfort levels among topics before coming into the program. The mean pre-program comfort level for all topics and combined was 2.51 (SD 0.50); this overall value fell in the range of only 'slightly' to 'moderately' comfortable.

Teacher reported post-program average confidence rankings changed dramatically after the conclusion of the program. On the low end, the topic of environmental microbiology persisted as being the least comfortable subject to teach (2.8, SD=0.63), although up one full point from the pre-program ranking. On the high end, 'the scientific method' again persisted at the top with a mean teacher rank of 3.8 (SD = 0.42), up only 0.2 points from the pre-program level. Interestingly, the topic of water quality and properties of water and estuaries also stood out as tying the highest reported post-program comfort level, increasing in rank by 1.3 points to a level of 3.8 (SD = 0.42). Post-program standard deviations ranged from 0.42 to 1.06, however, nine of ten topics fell between 0.42 to 0.63 SDs, indicating that relatively less variation existed among teachers for 90% of the topics after the program. The one topic that remained with relatively high variation was genetics (SD =1.06); this topic also received a relatively low post-program average of 2.9 points.

All pre-post individual topic comparisons showed highly significant increases in teacher reported confidence levels, with the exception of 'the scientific method'; although increasing slightly, it

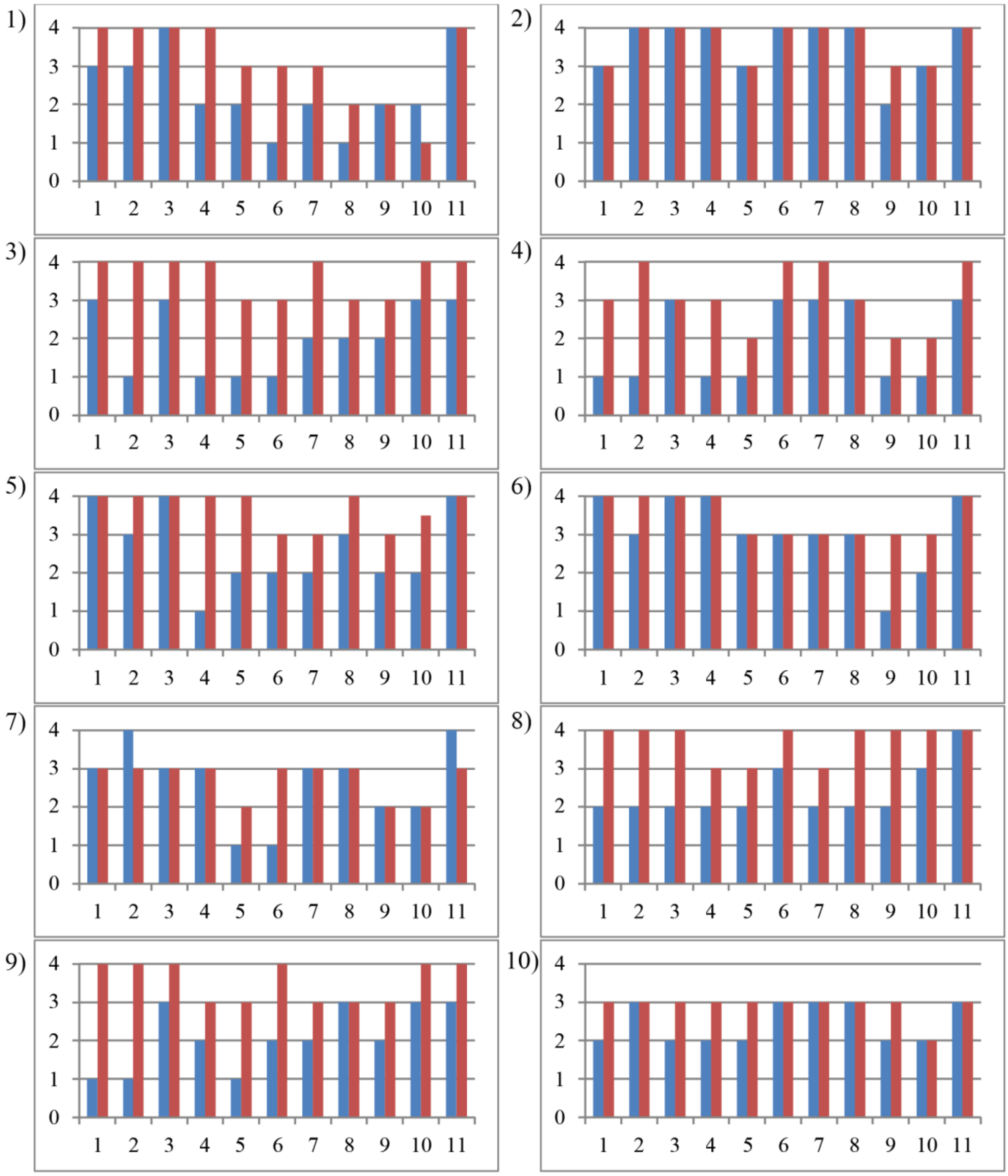

Figure 2. *Individual ranking scores (vertical axes) of ten participating teachers, in order from teacher 1 to teacher 10 from left to right, top to bottom of eleven science topics in environmental and marine biology (horizontal axes). 1) watershed processes, 2) water quality and properties of water, 3) ecology, 4) estuaries, 5) Hawaiian streams, 6) Hawaiian intertidal, 7) coral reefs, 8) marine biology and taxonomy, 9) microbiology, 10) genetics and 11) the scientific method. Blue bars are pre-program and red bars are post-program rankings.*

remained statistically unchanged. The mean overall post-program comfort level reported for all topics combined was 3.35 (SD = 0.36), an overall increase of 0.84. This pre-post overall difference result was also highly significant ($p << 0.00001$, see Table 4). Individual teacher results in pre and post responses can be seen in Table 5 and Figure 2.

Instructor Effectiveness and Teacher Intentions

Post-program evaluation results of instructor effectiveness and teachers' reported intentions to apply their newly acquired knowledge in their classroom teaching, as delineated by each of the four weekly themes, are shown in Table 6. In general, for all themes the teachers felt the program presenters were knowledgeable about the content, integrated hands-on application of the content, and were engaging and interesting while presenting the content. Minimum average ranking scores were 3.6 and maxima were 3.8 out of 4, indicating that the vast majority of participants indicated they 'agree' or 'strongly agree' with the effectiveness of the instructors. For the abiotic factors, ecological factors, and coral reef biology weekly modules, teachers indicated an average rank of 3.6 out of 4 when asked if they plan to apply what they learned when teaching their students. However, in the environmental biology section, teachers only ranked this section with an average of 3.0 points, indicating a slightly lower intention of applying this content to their classrooms. The average across all four weekly themes for all questions was 3.7 ('strongly agree') (SD = 0.39).

Expectations, Program Effectiveness, Standards and Implementation

The overall post-program evaluation results are shown in Table 7. In general, most teachers indicated that their experience during the four week program met their expectations, with an average ranking score of 3.7 (SD = 0.48). Generally speaking, teachers either indicated they 'agree' or 'strongly agree' that delivery of the program was performed well by the instructors. Similarly, most teachers agreed that the content was applicable to Hawai'i Content and Performance Standards and National Standard for their grade(s), and that they would implement what they learned in some way in their own schools in the next academic year. All ten teachers indicated with a ranking score of 4.0 ('strongly agree') that the program enhanced their professional expertise in marine and environmental science. However, a score of only 2.9 (SD = 0.57) resulted in reference to a question as to whether the content was appropriate for what their students should know and be able to do in science at their respective grade levels. Teachers also indicated that they were slightly less likely (2.9, SD = 0.57) to share their new knowledge with other educators outside of their schools.

Table 7. *Post program overall evaluation of effectiveness of experience (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree).*

Evaluation Criteria	Average	S.D.
The experience met my expectations	3.7	0.48
Content was organized around clearly articulated goals for participant learning.	3.7	0.48
The time was planned carefully and used effectively.	3.3	0.48
Content was presented using a variety of learning modalities.	3.4	0.52
Program enhanced my professional expertise in marine and environmental science.	4.0	0.00
Speakers were knowledgeable about content.	3.9	0.32
Speakers presented content information effectively.	3.7	0.48
I will implement what I learned in my own school/organization in the upcoming academic year.	3.3	0.48
Administrators in my school/organization will support me in implementing what I learned.	3.2	0.63
I will share information I learned with other teachers/educators in my school/organization.	3.4	0.52
I will share information I learned with other educators in other schools/organizations.	2.9	0.57
Program content was appropriate to what my students should know and be able to do in science at their grade level.	2.9	0.57
Program content was applicable to Hawai‘i Content and Performance Standards for my grade(s).	3.2	0.42
Program content is applicable to National Content Standards for my grade(s).	3.2	0.46
OVERALL	**3.4**	**0.26**

Post Program Teacher Feedback

A complete record of narrative responses to the post program evaluation questions are shown in Appendix II. In the first post-program question asking about which topics they liked the most/least, which were most useful, and which they wanted more information on, generally, most teachers indicated they enjoyed many of the topics and experiences and one commented that they "*truly enjoyed each of the four weekly topics*". Many also indicated they very much enjoyed the various fieldtrips, particularly to Waihe‘e Tunnel and the coral reef and ecology related field activities by expressing that they "*got many ideas for field trips to nearby locations and ideas for service projects*." Consistent with ranking evaluation results, narrative responses indicated that the environmental microbiology theme and associated activities were less favored and possibly too difficult to apply while teaching students.

In response to the question that asked what teachers would need to implement what they learned into their own classrooms, the overwhelming number of responses indicated financial constraints and lack of access to necessary equipment and supplies as the primary limitations to implementation as one participant lamented, "*Obviously, financial constraints top the list. I see grant writing for equipment and materials, borrowing some from Windward Community College, reprioritizing our science department budget as possible solutions. Field trips could be during non-school hours with personal vehicles*".

In response to the final question asking what recommendations teachers had to improve the program, teachers had varying responses but one concluded that, "*If there were ways the students and teachers could work together, that would be worthwhile. Having guest speakers and a variety of speakers was an excellent factor added to this class. Getting a DVD with everything from the class will be very useful too*." Other responses included slowing down the pace of the program, having less lab write-up assignments, including more mainland participants, incorporating students into the program, and collaborating in various ways with university scientists (instructors). Several teachers had no recommendations for improvement, but instead only communicated their enjoyment of the experience overall, as demonstrated by one enthusiastic participant, "*This was an awesome experience! I hope to have contributed as much as I obtained! [Instructors] were great! Thank you for providing this rewarding and inspiring* *opportunity! I depart with the spirit of Aloha, new bonds of friendship, and countless ideas to encourage stewardship in my students*".

Discussion

It is increasingly recognized that place based inquiry activities can be a powerful way to engage students in science (Aikenhead, Calabrese, & Chinn, 2006). Providing a context that is relatable to the individual brings meaning and personal experience into the learning process (Semken & Freeman, 2008; Wiener & Rivera, 2010). This is particularly applicable in places like Hawai'i in which communities reside in such close proximity to the ocean where they live, work and recreate (Wiener & Rivera, 2010). As practicing scientists and educators at the UH who have worked with a variety of other educators from informal, K-12 or university programs, we believe local teachers recognize that a pedagogical approach that incorporates local marine and environmental experiences will better reach Hawai'i's students and citizens. Consistent with our assumption, we found the open responses to our evaluation questions in both the pre- and post- surveys often indicated that teachers' motivations for participation included to (1) better relate Hawai'i based content to science teaching, and (2) improve environmental stewardship values in their students. Most importantly, participants in our program were successful in creating a diverse set of novel lessons plans based directly off of the experiences the program provided them. This was particularly true of the lessons developed from the abiotic and ecological factors themes, where both the content and the outdoor environment lent themselves well to creating place-based and investigative lessons. On the other hand, limited accessibility to in-water environments and the relatively high technical nature of laboratory work resulted in lessons within the coral reef biology and environmental microbiology themes being more limited. Nonetheless the teachers reported that all sections of the program contributed significantly to their overall professional development.

Given our backgrounds and training first as scientific researchers but each with histories working at the K-20 levels with students, teachers and education institutions, we have anecdotally noted that many teachers have expressed an unfamiliarity with the Hawaiian biological systems within which they teach, and often communicate they do not feel well prepared in teaching scientific inquiry and investigation. This latter issue has been noted widely in the educational research literature (Beyer, et al., 2009; Hume, 2009). Thus, in our investigation here, we sought to ascertain what the teachers participating in our program felt were their own shortcomings concerning an array of topics and content areas relevant to teaching marine and environmental science in Hawai'i, as well as how they felt about the more general concept of the scientific method. We determined such "confidence" through an assessment of self-reported comfort levels among teachers to teach an array of science topics using a Likert-scale instrument. While many studies have used confidence data as an indication of teaching efficacy (Garbett, 2003; Harlen, et al., 1995; Kind, 2009; Murphy, et al., 2007), relatively few have applied these evaluations in both pre- and post- program settings to determine the relative changes as a result of professional development. Those that did have shown statistically significant improvements as a result of professional development training (Turley, Powers, & Nakai, 2006).

The way in which our program was structured allowed for pre- and post-assessments to be made. As expected, we found that on average pre-program responses indicated that teachers were only 'slightly' to 'moderately' comfortable teaching these ten science content area subjects. Interestingly however, most felt they were 'very comfortable' with teaching the scientific method as a process. As scientists, we found this result curious given that the concept of the scientific method and the process of scientific inquiry are inextricably tied. Yet, while teachers reported that they felt comfortable teaching the scientific method, they simultaneously indicated as one of their motivations for entering the program was to learn more about scientific inquiry and investigation. We tended to notice through the course of the program that in actuality many of the teachers exhibited some degree of uncertainty with executing the scientific method within the actual process of inquiry and investigation. This observation is consistent with other findings in that teachers often don't realize what they don't know (Garbett, 2003), particularly when their backgrounds are weak in the subject area.

In reference to the ten different topic content areas covered during the program, while by in large we observed significant improvements in self-reported comfort levels across all ten subjects, there were a few exceptions. For example, one teacher (teacher 7) indicated that after the program he/she was 'comfortable' with the topic of water quality and properties of water, despite indicating a rank of 'very comfortable' before the start of the course. This same teacher reported a similar decrease in comfort ranking for the topic of the scientific method. Similarly, teacher 1 indicated he/she was 'slightly comfortable' with the topic of genetics before the program, and by the end indicated a rank of 'not comfortable' with genetics. Two teachers' (teacher 2 and teacher 6) rankings changed little in the pre and post analyses with the exception of slight increase in the environmental biology topics. The three teachers who indicated their degrees were entirely in the education fields and with up to 3-5 years of teaching experience ended up with three of the four lowest post program reported comfort level averages. Conversely, the two highest post program scores came from teachers with at least Bachelor's degrees in the life sciences and less than two years of teaching experience. These latter findings are consistent with other surveys of teacher confidence in teaching science. Such studies have revealed that teachers with science qualifications in their educational backgrounds and those more recently qualified to teach science were more confident than the more experienced (Harlen, et al., 1995). Nonetheless, while possessing robust subject matter knowledge improves teacher confidence, the ability to teach science effectively is not always alone a function of content knowledge. For example, it has been demonstrated that among teachers with strong backgrounds in a particular science field but who are tasked to teach outside their "science specialties" actually work harder to remedy their lack of confidence and competence in the subject field, despite expressing a lack of confidence to teach such non-specialty subjects (Kind, 2009).

One of the most curious results was the modest reporting of comfort levels from the single teacher with a Ph.D. in the life sciences and 3-5 years of teaching experience, who reported the third lowest post-program comfort level. We are uncertain how to interpret this latter result, though it could stem from an apparent difficulty (and hence, relative 'discomfort') in translating content knowledge at an advanced level to the high school level audience. High levels of subject matter knowledge may not necessarily equate to similarly high levels of pedagogical content knowledge or development effective teaching strategies (Kind, 2009). Alternatively, the result might reflect an underlying pattern that those most educated in the sciences respond more cautiously, as they are more aware of what they still don't know in the sciences, whereas those with relatively little knowledge in the science fields "don't know what they don't know", and thus report a form of "inflated confidence" in teaching the subject matter. Studies have shown that teacher perceptions of their own knowledge are sometimes at variance (i.e. less than) then their actual knowledge (Garbett, 2003). Exploring these questions further would be an interesting avenue to pursue in future studies. Whatever the case may be, these variable results provide insight into teacher's educational, experiential, and potentially even individual personality influences on reported outcomes, and that caution should be taken when interpreting this type of data, particularly with small samples sizes such as ours (Figure 2).

Nonetheless, by the end of the program, average self-reported comfort levels overwhelmingly improved and were statistically significant in all ten topics as well as overall. For the topics of microbiology and genetics however, in general, both pre and post analyses indicated somewhat consistently a relative discomfort with these topics (within the environmental biology theme). While rankings in environmental biology overall improved after the program, they were still noticeably lower than all other topics. This is likely related to the relatively complex topic and advanced level of technology involved in the lab and inquiry based applications in microbiology and genetics. As noted, developing lesson plans in these subject areas were less successful.

By in large, the results in terms of teacher reported confidence rankings suggest that learning from practicing scientific researchers, having the in-depth relevant expertise to provide professional development training to K-12 educators, can be an effective means of improving teacher confidence in teaching science and science inquiry. The post program evaluations results also showed that teachers agreed that learning science from scientists, both in terms of content (e.g. ten topics) and scientific process (e.g. the scientific method, inquiry and investigation), was a beneficial experience. Educational reform agendas (American Association for the Advancement of Science, 1993; National Research Council, 1996, 2012) consistently suggest that the practice of scientific inquiry needs more emphasis in science curricula, and that one of the main shortcomings to achieving this goal is that teachers themselves are not well practiced in scientific inquiry and investigation. Thus, professional development involving learning through practicing disciplinary experts can enhance teacher knowledge, and thus confidence in teaching in these subject areas. This is the basis of the efficacy of the RET model and one we tried to emulate, in part, during our program.

As far as plans for implementation, most teachers indicated that they planned to implement in some way the new knowledge they gained to teaching in their own classrooms. Most also agreed to some extent that they expected to have support from their school administrators in doing so. At the same time however, many teachers indicated in their written feedback that they expected limitations relating to not having access to funds to obtain the required supplies to implement new ideas. This appears to be a common finding among investigators on teacher professional development programs (Russell & Hancock, 2007; Sadler, Burgin, McKinney, & Ponjuan, 2010), and given the fiscal climate over the last few years and significant cuts to public school budgets, the result here was not surprising. One way teachers suggested to overcome some of these obstacles was to partner with the instructors and the university. Indeed, since the conclusion of the program, one of the investigators continued to work with at least four of the ten teachers in furthering their interests in implementing what they learned from the program. Two teachers were partners on a UH grant proposal to the National Science Foundation, one has brought students to do laboratory investigations at the HIMB, and one has sent a student to participate in a research internship at HIMB. Several more have encouraged their students to pursue summer internship courses designed and executed by the investigators/instructors of this program at WCC and HIMB. Thus, in addition to the content knowledge gained through the program, synergistic collaborations between teachers and with the instructors resulted. Despite all these opportunities, it is clear that fundamentally teachers are in need of additional support both administratively and fiscally in order to implement authentic and place-based science investigations in their classes, in accord with the plethora of recommendations at numerous levels of government and academia (American Association for the Advancement of Science, 1993; National Research Council, 2012).

Finally, some of the results and written feedback suggested that while the content was relevant to the state and national science standards, some of it (particularly the environmental biology topics) was too difficult for students. The instructors of the program were cognizant of this potential issue and in fact purposefully chose to pursue it as a program topic in an effort to ‘challenge’ teachers with modern techniques and use of technology in this section of instruction. While we were aware that the content was somewhat advanced for high school level students and that equipment to emulate these investigative techniques in the classroom would unlikely be available, we pursued these concepts with the intent of providing teachers with a well-grounded understanding of authentic scientific inquiry as it is currently practiced in the field of environmental biology. This we believed would only strengthen teachers' content knowledge and improve their comfort in teaching this complex topic, while bolstering their understanding of the process of authentic scientific inquiry. We remain aware of related limitations with implementation for other topics relating to funding for equipment and supplies. Thus, in addition to partnering with the participating teachers on grants and other educational programs at the university, we have been pursuing extramural funding to support equipment loans to teachers to facilitate implementation in their schools.

Conclusions

We undertook development of this program in pursuit of two main goals. Our first and foremost goal was to provide a rigorous, authentic science inquiry experience that capitalized on the rich environmental context of Hawai'i in an attempt to get teachers to better relate content, concepts and investigative scientific methods to local students that went beyond a single, in-depth research topic. Our second goal was to conduct a simple investigation of the perceived effectiveness of our professional development program in Hawai'i by ascertaining teacher participant feedback through evaluations. We believe that we achieved both goals through a valuable program that brought together K-12 and university educators that culminated not only in improved confidence in teachers, but catalysed synergistic partnerships that may have longer lasting and pervasive results. Our hope is that the framework we described here is of value to broader geographic regions and might be easily adapted by other organizations to develop similar programs in their respective backyards. Importantly, however funding agencies need to simultaneously consider better supporting development and delivery of place-based, scientific inquiry programs, knowing the potential benefits to students.

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[1] It should be noted there are important cultural distinctions between the terms 'watershed' and 'ahupua'a' not described here (Jokiel, Rodgers, Walsh, Polhemus, & Wilhelm, 2011).

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Appendix I.

Pre-Program Question: In a short narrative, describe what you hope to get out of this experience.

- Lesson plans I can implement in fall and ideas for field trips.
- Ideas for lesson/units on environmental science topics in Hawaiʻi that emphasize inquiry & project learning.
- I hope to develop and gather resources that I can take back and incorporate into my classroom. I hope to utilize these resources to motivate my students and instill in them a greater sense of stewardship.
- Learn more about how student can give back to environment in a hands-on way.
- A better understanding of the Ahupuaʻa concept and how to utilize it in teaching.
- I want to learn more about Hawaiʻi's ecosystems and learn how to bring that knowledge into my classroom. I hope to give my students a chance to explore the environment that they live in and understand how special Hawaiʻi is.
- I hope to gain materials and information that will help me better engage my students.
- How to relate curriculum to my students more and find out about different resources available to use in the classroom.
- I would like to become a great and innovative marine science teacher that gets kids interested in marine science fields after high school.
- Instructional expertise & content.

Appendix II.

Post-Program Question: What topics did you like best and which did you like the least? Which did you find most useful? Which did you wish you had more information on?

- 1. I got many ideas for field trips to nearby locations and ideas for service projects. 2. I got ides for classroom activities, labs, and lectures. 3. I established a network of people who can serve as resources for me.
- Like – Waiheʻe tunnel; unique experience for learning. Dislike – most

lectures; content was repetitive for me. Useful – field labs like bioassessment surveys of intertidal. More info – setting up activities for my classes, i.e., who to contact and if there are any requirements.

• I truly enjoyed each of the four weekly topics. If I had to pick one as a favorite, it would have been the abiotic factors. Being the first week, it was a great introduction to the educational and cultural experience I was about to have. Learning about the Ahupua'a and the trip to the Waihe'e Tunnel were amazing. If I had to say there was a least favorite or rank them in order, it would probably be the Microbiology topic simple because its implementation is not a practical in my classroom; however I truly enjoyed having the opportunity to go through the process and will at the very least be able to use some of the terminology in my classroom and expose the students to the cutting edge of science careers.

• I really enjoyed week - I would have liked more info on our Ahupua'a like tracing it from mountain to sea. I also enjoyed doing stream assessment in week 2. The coral stuff was fantastic but I knew a bunch about that already. I thought DNA was fascinating and the powerpoints extraordinary.

• Best, useful etc.: most of the course. Very applicable & oriented towards Hawai'i students. The last week's work, although conceptually important, was a little too difficult for non-honors or AP students.

• I loved all of the field trips – visiting places where I could take my students and giving me ideas for other field trips. I liked getting ideas on how to integrate watershed and coral reef topics into the required standards. I also learned a lot about microbiology that will help me teach this topic better.

• I enjoyed this course very much. [Instructors] did a great job. It also gave me an idea what teachers on the other side of the country were doing, very helpful and insightful. This class did a good job varying instruction, we did several different things in one day so nothing got very boring.

• I liked best the coral reef and ecology labs. I had fun and it didn't feel like work. Very interesting and relevant to me. It would have been nice to compare our data with what others got and even more so with the students. The topic I was not too crazy with was (if I had to pick) [Environmental Biology Lab]. What I didn't like was how it was difficult to determine what exact kind of bacteria we had. It was a little discouraging. I found it very interesting and I liked how this lab was inquiry based.

• Coral reef ecology was the most interesting topic with the best lesson plans. I would like more information on how to incorporate abiotic factors with oceanography.

• I liked all the topics and found the excursions and powerpoints really interesting and informative. I wish I had more information on the powerpoints because I'm not sure if I will be able to interpret all the slides effectively – but I will try and research concepts or slides I didn't quite understand.

Post-Program Question: What support do you think you will need to implement what you learned into your classroom?

• Two short-comings of [the program]. 1. The lessons are not immediately implementable in the classroom. They still need work and adapting, e.g., worksheets, quizzes. 2. Teachers need to borrow equipment, such as environmeters, salinity meters, GPS, in order to implement lesson plans.

• Technology and equipment is biggest roadblock for me with many of the lab activities. I will need to look for alternative or to purchase test kits, water quality kits, etc.

• Aside from the equipment, 95% of what was learned in this class is applicable to my setting. It would be nice to have planning time from my district to incorporate these new ideas. I will definitely make changes to my current lesson plans to integrate or supplement this new content.

• Obviously some of the equipment would be good. I think having my lab reports will help me remember and set up. I don't have any of the tools to implement. It would be great to have some guest lecturers – i.e. you guys!!

• Obviously, financial constraints top the list. I see grant writing for equipment and materials, borrowing some from Windward

Community College, reprioritizing our science department budget as possible solutions. Field trips could be during non-school hours with personal vehicles.

- I would love to have access to materials we used such as water quality meters, bacteria growth trays, spectrophotometers and gel electrophoresis.
- I will use the notebook I was given as well as resources on the web. I also have e-mail addresses if I need them.
- The tools used in the lab. My school doesn't have the money. If we received emails about relevant grants that could help us, I would definitely apply for them. Money seems to always be a factor. Supplies and materials to do these various kinds of labs would also help, even if they are hand-me-downs from retired teachers or from the college.
- Supplies, more training/classes.
- More practice with the material – especially the powerpoints. Access to lab equipment.

Post-Program Question: What other comments or recommendations do you have to improve this program?

- This program was very beneficial to me. I especially enjoyed the hands-on aspects and the culture-based curriculum. I appreciated the hard work and preparation the instructors put into the program.
- See the "more info" section above.
- This was an awesome experience! I hope to have contributed as much as I obtained! [Instructors] were great! Thank you for providing this rewarding and inspiring opportunity! I depart with the spirit of Aloha, new bonds of friendship, and countless ideas to encourage stewardship in my students.
- For the DNA – I would like to pair my high school kids with a UH science professor for a project. My kids could gather samples and do the plating, send it to college kids to do the rest of the lab. They could feed us the sequence to figure out species OR even better my kids could come to college lab to work along side the college kids. This would be extremely powerful experience. Write a grant [instructor] – Or I will write a grant and we can collaborate!
- Nothing really; perhaps not trying to cram too much into one day. For my students, I'll need to move more slowly, e.g. a week or more prep (concepts, organism ID etc.) before fieldtrip to intertidal zone or coral reef. All in all, great program. Thanks for the opportunity!
- First week should only have one formal lab write-up. The soil and water labs could be designed just to submit the data.
- Inform people of some of the hazards in the field. Not everyone knows about the killer cone snails! I think the class benefited from a mix of island and mainland teachers. We learned a lot from each other. You may want to include mainlanders in the future too! Thank you very much for making our time on the island an enjoyable one. We really appreciate all you've done for us.
- If there were ways the students and teachers could work together, that would be worthwhile. Having guest speakers and a variety of speakers was an excellent factor added to this class. Getting a DVD with everything from the class will be very useful too.
- Collaborate with interested teachers beforehand to ask them of the needs of their classrooms/students.
- It was pretty fast paced, but I understand it needed to be. In some lessons (i.e., genetics, microbiology by [instructor]) it may have meant more to me if we had the powerpoint/lecture first. I learned a lot and believe the skills will be very useful this coming school year.