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STEM in Hawaii: Exploring the Impact of an Innovative Field Trip Experience on Pre-Service Teachers

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Abstract

Field trips have been recognized as a useful educational tool in teacher education programs, although creative and broad use of them as a vehicle for teacher training has been limited. This study explores how immersive field trips integrated into an interdisciplinary, research-based Study USA course to Hawaii impacted the learning of teacher candidates. Based on an analysis of qualitative data, the study found that pre-service teacher participants made substantial perceived gains in acquiring domain-specific content knowledge and pedagogical skills related to STEM learning, and positively impacted their interest in STEM fields. Findings from the study have important implications for practitioners and field trip designers in helping pre-service teachers become more competent in teaching STEM-related courses.

***Keywords**: Experiential Learning, Field Trips, Informal Science Instruction, Interdisciplinary STEM Education*

Introduction

Field trips to authentic settings such as museums and science centers have long been recognized as a useful educational approach and powerful tool for enriching student learning experiences. The impact of these types of informal learning environments has been well researched in the existing literature, and it is clear that such trips have the potential to provoke positive attitudes towards a certain topic or subject (Nadelson, & Jordan, 2012), arouse participants' interest (Bonderup Dohn, 2011; Cha, 2001; Bell, Lewenstein, Shouse, & Feder, 2009), improve academic achievement (Houser et. al., 2011), and foster critical thinking skills (Morag & Tal, 2012). However, most of existing studies focus on informal learning trips that are either short in duration (1-2 days) and/or involve a limited set (1-2) of learning venues. Few studies focus on the combination of traditional indoor and outdoor informal learning environments. Moreover, field trips that maximize participant learning are rarely incorporated into teacher education programs (Olson, Cox-Petersen, & McComas, 2001), largely due to funding limitations and time constraints (Behrendt & Franklin, 2014). The fact that in-class teaching remains a dominant format for teacher education programs has led to science teacher candidates being inadequately prepared to provide such experiential learning opportunities for their students, despite their demonstrable benefits (Martin-Dunlop & Fraser, 2007).

Relevant Literature

Many studies have been conducted to examine the impact of field trips to informal learning environments such as museums and aquariums on pre-service teachers. A majority of these studies describe a positive impact of such trips on participants' acquisition of subject matter knowledge and pedagogical skills, while others shed light on the learning outcomes related to the affective domain.

In the subject knowledge and pedagogical skills aspects, several studies reported positive findings. Kisiel (2013) examined the perception of pre-service teachers enrolled in a science methods class had towards informal science education institutions (ISEIs) and found that instead of viewing the ISEIs as merely destinations for field trips or hands-on experiences, the pre-service teachers learned to value the utility of ISEIs as places that not only provide resources for classroom teaching but also assist them in learning content knowledge and good pedagogical practice. In contrast to Kisiel (2013) who reported both content and pedagogical benefits, several other studies focused specifically on pedagogical benefits. For instance, Çil, Maccario, & Yanmaz (2016) investigated the impact of an innovative 3-stage museum visit on pre-service elementary teachers in Turkey and found that their museum-based teaching strategy had a positive impact on the participants pedagogically. In another study conducted by Morentin and Guisasola (2015), the participating pre-service primary teachers who enrolled in a master's level method course were involved in the design and implementation of a teaching unit plan that focused on visits to a local science center. Morentin and Guisasola (2015) found that the participants grew in their practical understanding of pedagogy.

Examining the how three different informal science learning experiences embedded within an elementary science methods course influenced the perspectives of pre-service teachers on science teaching and learning, Avraamidou (2015) found that such experiences help pre-service teachers develop better inquiry-based approaches. In a more recent study, Alon and Tal (2017) used a mixed method design with 20 field trips to investigate how outdoor educators use field trips to natural environments. Among the eight types of learning outcomes they reported,

structured active learning was identified as the prominent factor in helping participants benefit from such field trips.

In addition to pedagogical benefits gained by participants that engage in informal learning environments, other studies report benefits related to affective learning outcomes such as gaining confidence in teaching and organizing future field trips, as well as sparking interest in some domain-specific subject(s) or topic(s). In one study, Anderson, Lawson, & Mayer-Smith (2006) found that by involving secondary pre-service science teachers in a prolonged practicum model with a required field experience component at a local aquarium setting, the participants' self-confidence in teaching was increased. This finding is also supported by the work of Hsu (2016). Working with local museums, Hsu (2016) designed a study in which undergraduate students enrolled in a science methods course prepared lesson plans for the Science Circus Days event, then presented their lessons to the public including K-12 students at a local museum. Hsu (2016) found that vigorous preparation of the lesson to be taught within a museum environment helped pre-service teachers acquire the necessary confidence in teaching via insights gained through the process of feedback, reflection, and observation.

Several studies report on participants' increased confidence in organizing field trips. In one such study, Authors (2015) revealed how engaging pre-service teachers as chaperones of middle school students on a two-day field trip provided the pre-service teachers with a unique opportunity for understanding student behavior in and out-of-the-classroom setting and improved their self-efficacy in leading young students on future trips. By investigating past field trip experiences and self-efficacy of pre-service teachers majoring in biology to plan and organize field trips, Bozdogan (2015) found that pre-service teachers acquired confidence in organizing field trips for their own students as a result of participating in field trips related to their program of study. Furthermore, Ateşkan & Lane (2016) examined the long-term effect of field trip planning, implementation and evaluation on the participants who are alumni of the biology department. They found that the field trip experiences enhanced the participants' confidence level in planning and organizing field trips and can provide a good model for other institutions interested in evaluating field trip preparation programs. Similar confidence benefits were reported by several other researchers, such as Anderson et al. (2006), Bozdogan (2012), and Johnson and Chandler (2009). Dawborn-Gundlach et al. (2017) studied the impact of a collaboration between a university teacher education program and a museum on contextual learning and found that participating pre-service teachers' interest in Earth Science was provoked and that participants learned to identify links to other areas of science.

Existing studies demonstrate how field trips can play an important role in providing valuable opportunities for empowering participants in terms of content knowledge and pedagogical skills acquisition, as well as affective outcomes such as confidence in teaching and, organizing field trips, and deepening interest in specific subject matter. However, it seems that there has been less innovation in the *design* of informal learning trips. On the one hand, the participants in the reported studies were only involved in one or two informal learning venues. Studies using intensive field trips that span more than one type of informal learning venue such as museums, aquariums, nature sites, labs, non-traditional schools, etc. are rare. On the other hand, the existing studies also show a lack of innovative design in the composition of the participants. To further help the pre-service teacher participants acquire deeper and more profound content knowledge, it may be beneficial to have participants from the corresponding content department as well. Bringing the pedagogy department and content department together is hypothesized to enrich the experiences of both pre-service teachers and students from non-education departments on field trips.

This study was undertaken to investigate the benefits and impact of an interdisciplinary, hybrid, research-driven Study USA trip to the Hawaiian island of Oahu on pre-service teachers' STEM learning, as afforded by the collaboration between instructors with pedagogy and specific STEM-content (biology) expertise.

Theoretical Framework

Situated Learning Theory (Lave & Wenger, 1991) was used as the theoretical lens through which the learning of the pre-service teachers could be explored and interpreted within the context of authentic informal social learning. Lave and Wenger (1991) argued that learning happens in a situated context through what they called a "legitimate peripheral participation" process, in which the learners participate in a "community of practice" to acquire certain knowledge or skills. Through observations and interactions with the expert, the novice learners gradually move from the periphery of the community toward full participation in its social, cultural activity, which leads the learners to the acquisition of the skills and knowledge embodied in such community of practice. The fundamental idea of Situated Learning Theory is that learning is a social process that relies on real life situational context, where relevant knowledge or skills to be learned are embedded (Lave & Wenger, 1991). As such, social interaction and collaboration become essential components of situated learning. Using Situated Learning Theory as a guiding framework, we aimed to understand the pre-service teachers' learning in a real life situated context — the Hawaii field trip.

Materials & Methods

Context and Participants

This qualitative study was conducted during the Winter Intersession of 2016-2017 academic year in conjunction with a Study USA course at a mid-south public university. Study USA courses give students the opportunity for experiential learning throughout the United States while earning college credit. This class was conceived of as a dual enrollment course with content specific science and STEM education pedagogical components. The idea was for pre-service teachers to witness and participate in "real" science research in action in the field, gain science content knowledge, and learn methods for teaching science most effectively in the classroom. The course itself, as outlined by the Study USA office, was to be a week in length with a minimum of 37.5 contact hours of instruction. The course was scheduled during the winter intersession in January between the fall and spring semesters. There were two additional days, 6 hours each day, on campus in December following the fall final exam week and prior to the time in the field.

A Teacher Education professor in the School of Education (second author) recruited a professor in Biology (last author) to create the course together. The underlying motivation was to expose pre-service teachers to another region of the United States, and also to show soon-to-be teachers what real scientists do. Both faculty members worked to plan the course, creating most experiences for students to experience together, but with some activities specific for students in each major. Both faculty members took responsibilities for being the primary instructor for one of the days in December, and they coordinated their efforts to plan the week on the island of Oahu.

The biology professor is a microbiologist with interests in the evolution of symbiosis, particularly focused on fungi and photosynthetic microbes (algae and cyanobacteria). In his work, he gathers "samples" from an environment from various substrates (e.g., soil, tree bark, leaves, rocks), processes these samples to place them in nutrient culture medium, and observes what grows for the purpose of identifying new microbes and understanding how microbes interact. The education professor specializes in elementary mathematics methods, but as a former elementary school teacher, she is interested in the integration of content areas and contextualizing content for authentic learning experiences. They both have a strong passion for STEM education in the K-12 schools, both of them agreeing that science and mathematics teachers are often ill-prepared to teach science or math effectively in ways that engage students, encourage deeper learning or inspire students to continue on in STEM fields. Because of this shared belief and a shared vision for using a travel study class to address the problem, the course was created and approved by their respective departments and deans.

In addition to the pedagogical goals stated above associated with intentionally having a mixed education-biology cohort, this hybrid course was designed to have a research-centric approach, giving all students a real taste for how scientists might interact with nature and study it. All students participated in the sampling microbes from several natural Hawaiian sites and used essentially the same experimental methods developed and used as part of a current NSF-funded research project directed by the last author. Students also engaged with researchers and scientists in person, and by reading instructor-selected research articles written by them. In addition to the pedagogical research questions posed for this course, there were several science-specific course objectives for the students of this course, including: (1) to better understand how science is conducted and how it can be effectively communicated, (2) to have a deeper appreciation and understanding of how "unseen" microbes and symbiosis (persistent physical interactions) shape the landscape and diversity of biological life, (3) to learn how to read through a biological research journal article (primary literature) and confidently engage with research scientists about their work, (4) to develop basic skills and understand the basic workflow for isolating microbes from environmental samples and how to process them in the laboratory, and (5) to appreciate the interaction between science and culture/society, and it's relevance for STEM education and communicating science.

This course was open to all students on campus, undergraduates and graduate students. Students could enroll under the education course number designated for "Special Topics." Biology majors, with the prerequisite courses could take the course to fulfill graduation requirements. Other interested students could take it under an environmental science course number. Enrollment of the course included eight students majoring in education and another eight students majoring in biology, with all the education students being females and the majority of biology students being males. Of the eight students in education, four were undergraduates (two juniors, two seniors), three were Masters level graduate students and one was a non-degree seeking student. All of the education students had an interest in STEM education, either focusing masters level work in science and mathematics or seeking a Bachelor's degree with a secondary teaching license in mathematics. Even the elementary education majors were on track to earn endorsements to their state teaching license in mathematics or science. These students were interested in knowing more about how STEM education is presented in elementary and secondary classrooms. The eight education students became the participants of the current study.

Field Trip Design and Procedures

The overall goals of the course and the variety of learning experiences students participated in to achieve such goals during the trip are presented in Table 1. Education students were provided with tours of charter schools whose curricular foci are on STEM concepts and/or cultural emphasis, as well as training in *Project Learning Tree* (www.plt.org) curriculum.

Table 1: Goals of Course and Related Activities

Goal	Course Activity
Experiences as field researchers in biology	Field sampling in Kualoa Ranch forests Sample processing and culturing of microbes at the University of Hawaii-Manoa (Department of Botany)
Experiences with inquiry-based instructional strategies in the context of a STEM unit of study	Engage in *Engineering is Elementary* kit activities (www.eie.org) Keeping a science notebook; Met with author of *Science Notebooks*, Dr. F.
Presentations by research biologists	Met Drs. M., R., H. at the Kewalo Marine Laboratory, research on Vibrio bacteria and Bobtail squids, etc.

	Toured Coconut Island: Hawaii Institute for Marine Biology
Presentations by educators in ISEIs	Met with K. I. at the Waikiki Aquarium on development of museum exhibits
A deeper understanding of culture and how one's culture impacts daily life	Met with M. L. at Kualoa Ranch Education Center Luau dinner together at Germaine's Luau
Experiences for Biology Students Only	Further sampling at Lyon Arboretum, Aihualama and Manoa Falls Science discussions with professors at UH-Manoa, Drs. A, H, and S.
Experiences for Education Students Only	Visitation of two charter schools, one with a focus on Hawaiian culture and one with a STEM focus

During the two pre-trip days on campus, the students were provided with an orientation as to what to expect for the course, a first-encounter (practice) experience with the methods that were to be used in the field, and the content to be explored in the course. The first day was designed to give students a primer on biological field sampling and culturing of microbes, which they would use during the field course. The second was to experience and analyze the STEM unit design of the Engineering is Elementary (EiE) kit: *Water, water, everywhere: Designing water filters* (https://www.eie.org).

Both instructors were involved in both days of instruction, and both groups of students were taught together. Particularly for the field research aspects of the course, students were partnered up: one biology student with one education student. In the sampling lesson, students went outside to collect samples on the college campus, and then processed the samples to microbial cultures as routinely pursued in one of the instructor's research lab. The students were also given a primer on how to keep a research-level scientific (laboratory) notebook and given a guide with further details to study (http://www.ruf.rice.edu/~bioslabs/tools/notebook/notebook.html).

For the STEM lessons on the second day, students were instructed to come prepared by completing the reading as homework, which provided a context for the water filtration teaching module. Students went through an abbreviated set of lessons to build and test filtration apparatus and then were charged to design a "best system" to filter water containing "unknown pollutants." Students discussed how science understanding was applied to create a solution to a problem, as an engineer would implement in a real life situation through the use of the Engineering Design Process.

Throughout both days, all students recorded data in their science notebooks. Students were given a suite of articles by scientists whom we were to visit, and were asked to choose a partner (Biology student with Education student) and choose two articles to study, read, and prepare questions for each of the relevant scientists over the Winter/Christmas break (at least four on science and one on non-science matters). Students were also asked to complete readings from the following required course texts:

- *In the Company of Microbes: Ten Years of "Small Things Considered",* by Elio Schaechter (Schaechter, 2016)
- *The Squid, the Vibrio & the Moon*, by Ailsa Wild, Aviva Reed, & Dr. Gregory Crocetti (Wild, Reed, & Crocetti, 2014)
- *Science Notebooks: Writing About Inquiry* (second edition), by Lori Fulton & Brian Campbell (Fulton & Campbell, 2014)

The students were assessed based on their participation in the course, as well as several written assignments. First, their science notebooks were turned in and evaluated based on completion and quality of writing on the scientific activities for each day. The quality was judged based on the information provided to students during the December days, and through the *Science Notebooks: Writing About Inquiry* (Fulton, 2014) required text. Second, students were required to document their observations and experience in the course each day via an online blog; one pre-trip and one post-trip reflection blog entries were also required. Finally, there was a choice of cumulative project options that demonstrated both competence in a topic addressed in the course and the ability to communicate that knowledge to a lay audience: e.g., a teaching unit for a specified age group, a publicly available informational display (like a website) or a plan for a museum type exhibit, or another agreeable deliverable that was instructor-approved (e.g., some students discussed creating a rap music video with accompanying liner notes).

The participants engaged in hands on activities, both in the field and in the laboratory, collecting, enriching, culturing, and isolating microbes from their native habitat. Microbes were sampled from several natural Hawaiian sites including Kualoa Ranch, Lyon Arboretum, and Manoa Falls. The participants met with education specialists at the Waikiki Aquarium and Kualoa Ranch to understand education in non-school settings as well as the integration of biological engineering in K-12 schools. Participants visited the Kewalo Marine Lab, the Hawaii Institute for Marine Biology, the Bernice Pauahi Bishop Museum, and spent time in natural Hawaiian settings learning from scientists about the microbial symbiosis in Hawaii and experiencing the impact of symbiosis recreationally by snorkeling among a coral reef system at Hanauama Bay. They also learned from native Hawaiian educators specifically about the entwinement of nature, culture, and education.

Data Collection

Data collected for this study was obtained from participants' science notebooks, blogs, and projects that all education students were required to complete, along with pre- and post-trip reflections submitted by students on a Qualtrics survey. Small focus group interviews were also conducted to further contextualize the perspectives and self-reflections of what and how the participants learned from their experience and what the impact of interacting with content professors and peers might have had on their learning experience.

Participants' science notebooks, blogs, and pre- and post-trip reflections as well as interview transcriptions were analyzed qualitatively to derive initial codes by the researchers separately. The codes were then compared and any disagreement between the researchers were discussed and resolved to achieve inter-rater reliability (Maxwell, 2012). Major themes were thus developed to describe the participants' experiences in order to answer the research questions of this study.

Findings and Analysis

Data analysis revealed that the participating pre-service teachers acquired considerable gains in biological content knowledge, pedagogical knowledge and skills. Moreover, the data revealed that the experience had stimulated and deepened the participants' interest in teaching as well as in the field of biology in general, even if that was not an area of stated interest prior to the course.

Gains in Biological Content Knowledge

Before reporting on participants' gains in content knowledge, it is useful to first understand the participants' prior knowledge in biology. Before the trip, almost all the participating pre-service teachers noted explicitly that they had "a great deal of anxiety," as everything they were going to do "seemed so foreign" to them. Also, most of

them noted a "lack of background knowledge" by saying they do not "know a thing about microbes, let alone biology in general." One participant even shared that when she first started reading the assigned chapters from their textbook "In the Company of Microbes" by Moselio Schaechter, she felt "confused, overwhelmed, and just wanted to call my mom." The participants obviously lacked background knowledge of microbiology, which in turn generated significant anxiety in them. Interestingly, the participants were not intimidated by such a high level of anxiety or lack of prior knowledge to the extent of withdrawing from the course. We surmise that this may be due in part to the appeal of course destination and opportunity for adventure in Hawaii and/or engaging with the students during the December orientation days; but it appears to be also due to student confidence in the skills they already possessed and their potential for learning new things, as noted by one participant:

> "However, what I do have is a very special set of skills in the field of education, and I am very confident that I can utilize my teaching and learning skills to tap into the biology side of my learning potential."

As the participants started to collect microbe samples during the first of the field experiences in Hawaii, their confidence and positive disposition indeed helped them overcome hurdles and enabled them to reach a point of having fun with the biological field work. One participant shared that:

> "Today we visited Kualoa Ranch where we went on a walking tour and did some field sampling. I was worried that the biology aspects of today regarding the sampling and lab work would confuse me and/or stress me out, however all of the information we learned during the workshop made this very easy and enjoyable. Collecting samples out in this environment was really fun and didn't feel like the typical dreaded schoolwork."

(Note that prior to the first sampling session in Hawaii, the biology instructor reviewed the sampling protocol discussed prior during the December pre-trip orientation.) To add on to that, the participant's excitement at seeing growth from the moss sample she collected was the best indication of her progress:

> "When we went back to the lab we checked the plates we did on Saturday and I had growth!! Some bacteria from a moss sample really took off in my plate and I'm excited to check back tomorrow and see what pops up."

As the participants expected, they made remarkable progress in understanding the biology addressed during the seven-day experience. The participants visited Kewalo Marine Lab as one of their field trips and met with prominent scientists who spoke to them about the work they do, for example, on the symbiotic relationship between bobtail squid and the bacterium *Vibrio fischeri*. The participants noted that these lectures really helped them "better understand symbiosis." Another participant shared that "I learned more than I ever imagined about microbes and symbiosis, both of which were very foreign concepts to me before embarking on this trip." This resonated well with another participant, who commented that: "I am amazed at how much I was able to learn and accomplish in just 7 days, especially considering my initial lack of biological knowledge and understanding."

In addition to the above reported gains in content knowledge, the participants also noted several "life" insights that they gained in preparing for and during the course. Several required pre-trip readings have stimulated the participants to ponder the importance of microbes, with one participant sharing:

> "Chapter 44 of the text was also very thought provoking for me. As I learn about microbes, I realize just how many species we share this world with. Similar to Dr. Seuss's "Horton Hears a Who", the microbes are living in their own little world and interacting in their surrounding environment just as we humans are in a larger sense. This chapter helped me understand the impact microbes have on the environment in which we inhabit and how microbes can affect our day-to-day lives as humans."

This participant even shared the insight that she gained from the reading by stating that "[j]ust because you can't see something, doesn't mean it isn't important or can't affect anything. Without microbes, we would not have this planet, therefore, I agree with the author that this is not the humans' planet."

Such insight, regarding the importance of microbes invisible to human naked eyes, was a target concept for the course, and was further developed when the participants were provided with the opportunity to learn about microscopic plankton by examining them under a microscope during their field trip to the Hawaii Institute of Marine Biology on Coconut island. One participant exclaimed that she "never knew there could be so much information on such a small organism" and admitted that she was surprised at "how many there could be in only a few drops of water!" Furthermore, the participant learned an important grand lesson from this experience:

> "The biggest take away for me on this trip is to not take life for granted, there's a trillion little things that we share our world with that we never get to see, think about your actions and how they affect the world you share with others, and value the culture that is yours."

Such comments about the insight this participant obtained during the lab visit resonate extremely well with the perspective that the other participant gained regarding microbes when she finished reading Chapter 44.

The gains in content knowledge observed here by the participating pre-service teachers is consistent with other prior studies (e.g., Kisiel, 2013). However, the design of the current study – combining pre-trip preparation through readings and lectures with the actual course in the field – made it possible for the participants to dive much deeper into the subject matter. The important insights that the participants gained from the pre-trip readings and on-trip hands-on discoveries indicate that the design of the field trips facilitated participants' understanding and contextualization of biological relevance beyond merely learning biological facts.

Gains in Pedagogical Knowledge and Skills

In addition to gains in content knowledge, our analysis also revealed that participants acquired significant gains in pedagogical knowledge and skills. At the Ho'omaluhia Botanical Garden in Kaneohe, participants had the opportunity to attend a training session of Project Learning Tree, a program offered through the Sustainable Forestry Initiative, Inc. that connects teachers with resources to enable them to integrate environmental studies into their math, science, art, and language arts classes. One participant recalled that she was "already impressed with this [the brown bag activity] scientific inquiry task" within the first five minutes of the workshop, and admitted that "[t]he training was so worth the whole trip to Hawaii honestly." Another participant shared that she was "very excited to use" what she had learned during that day in her future classroom. Still another participant commented that she was "hoping to get more of them [students] interested in Project Learning Tree and hands on activities."

At Hawaii Institute for Marine Biology on Coconut Island, the participants took a tour of the facility followed by some hands-on discovery activities. For one of the activities, they were given a pile of seaweed (which they saw extracted from an adjacent body of water) and a checklist, and asked to sort through all the plant matter to catalog the variety of organisms found according to six different placards showing biological groupings. The participants noted that "[t]his was actually really fun and educational! Instead of teaching us about the organisms through a lecture, they taught us using a hands-on activity where we would identify, classify, and sort the organisms."
At Bishop museum, the participants had the opportunity to play with an "interactive sand table." One participant shared that she was "fascinated by this entire concept" and wished she had this tool when learning about the Earth's geographical features. Additionally, she commented that this concept would hopefully be further

developed so that she would be able to get one for her own future classroom to enrich her students' learning experience.

The participants also reported considerable pedagogical insights from listening to and interacting with educators that the course instructors had pre-arranged. The speakers included professors at the University of Hawaii-Manoa and the principal of the School for Examining Essential Questions of Sustainability (SEEQS).

Among several professors that were invited to speak to the group, the participants specifically remarked that they learned significantly from Dr. F., an expert and author of "Science Notebooks: Writing About Inquiry, 2nd Edition" (Fulton & Campbell, 2014). The conversation with Dr. F. sparked the participants to critically reflect on their own teaching methods. One participant particularly noted that "[a]s a future educator, learning about the use of scientific notebooks in the classroom from the actual author was an incredible experience." During the meeting, Dr. F. also addressed questions from the group and talked about keeping a science notebook and the pros of not grading the notebook for specifics, rather encouraging them to keep a very accurate record so they may use it on a test. This idea was applauded by the participants and the benefit of such an approach was noted by one participant:

> "I think that is a neat idea because people like to take notes in different ways and I would rather my students become comfortable taking notes in a way they can actually learn from them, rather than regurgitating my ideas back to me. It lets them be creative but at the same time they are still learning."

One participant, who was majoring in math education, realized that some of the ideas discussed by Dr. F. transcended disciplinary domains:

> "Even though I am a math education major, I think I can still tweak the science notebook idea to work for my math classroom, because learning how to write in a scientific manner is very practical for life beyond high school whether they go to college or go straight into the workforce."

The participants acquired pedagogical insights not just from professors but through visits to the two charter schools (Malama Honua Public Charter School and the School for Examining Essential Questions of Sustainability) and meeting with one of the school principals. More than one participant shared that getting to see Hawaiian charter schools may have been their "favorite part of the entire trip" and that the day to the charter schools was the one they were "looking forward to the most." The charter schools were so different from anything the participants had previously experienced, causing several of them to use the phrase "blew my mind" to describe what they observed there. These charter schools were chosen because their curricula have a strong focus on technology, project-based learning, and traditional Hawaiian values. One participant noted that at their own university, there is often only in-class discussion about how to create project-based learning experiences for students. However, visiting the charter schools actually provided them with the opportunity to "see these practices in action." One participant commented: "[o]verall, this was a very interesting and educational experience that makes me want to consider teaching at a similar school."

At the School for Examining Essential Questions of Sustainability (SEEQS) charter school, the participants met with the founding principal who spoke to them about the history, mission, and curriculum of this non-traditional school. One participant remarked that speaking to the principal was "mesmerizing" and she "couldn't help but hang on [to] every word" that the principal said, as if everything she was saying was "advice and wisdom." One participant shared how this experience of meeting with the principal and visiting SEEQS caused her to rethink her philosophy of education along several perspectives. Firstly, she realized the critical "importance of a strong leader," something she did not consider as important as the classroom teacher before the school visit. Secondly,

she observed how the "unique community and environment of the school," drew her in to have "intellectual conversations with the students, see the teachers teach, and partake in the fun and cultural activities" during the entire time she was there. Thirdly, she saw how the "curriculum [seemed to be] more significant in the success of the students than the specific techniques of the teachers." The participant also shared that if she would ever be in the position of designing curriculum for a school, she would turn to the SEEQS curriculum for "inspiration."

Perhaps a more remarkable pedagogical lesson was demonstrated by another participant's comment regarding her field sampling experience during which she encountered failure:

> "Today was also a big day for me introspectively. My partner and I had a few problems sampling (we put the water in 30 mL tubes instead of Whirl-Paks and lost a Whirl-Pak up on one of the ridges) and we also had a little trouble understanding the plating process. I just felt so dumb, everyone else seemed to be catching on just fine and I couldn't even move without almost spilling the sterile beads or asking questions because I didn't get it. I told [Dr. E] how I was feeling and he told me that you have to fail in order to do it correctly. While making me feel a little better, it also resonated with me. I've been struggling with the fact that I can't do everything perfectly, and this was just another one of those moments. Then it kind of clicked later that failing is really all science is. Science is just a process where you continuously fail in order to make something better."

By relating this experience to her future teaching, the participant added:

> "If I am going to be teaching math and science to my future high school students, I really need to grasp the concept that a little failure is not bad. After this little epiphany, I felt a lot better and more confident with plating our samples that we found at the ranch."

Overall, the participants shared very positive personal reflections in regards to their gain of pedagogical knowledge and skills. Their comments unanimously supported the benefit of experiential learning and project-based learning. One participant mentioned that as a current student and future educator, this trip "strengthened" her belief in "experiential learning, cultural integration, community involvement, and project-based learning." Another participant shared similar comments by saying that "[t]ouring the schools in Hawaii and attending the Project Learning Tree workshop" gave her "a whole new world of perspectives for project-based learning" that would greatly influence her own teaching methods. She further added that she felt much more confident that she would "be able to implement similar forms of experiential learning" into her future classroom. Yet another participant commented that the whole experience prominently reshaped her philosophy of teaching, as she put: "I can honestly say that this trip caused me to redefine my philosophy of education, and it gave me new ideas and goals for my future career."

The above findings related to participant gains in pedagogical knowledge and skills is consistent with prior studies by Çil, Maccario, & Yanmaz (2016), Morentin and Guisasola (2015). In particular, the participants' emphasis on project-based learning and experiential learning is similar to what Avraamidou (2015) found about participants' development of inquiry-based science teaching and learning ideas, as well as what Alon and Tal (2017) found regarding the impact of structured active learning on participants. These pedagogical gains can enhance the participants' commitment to teaching and confidence in teaching, as was found by Anderson, Lawson, Mayer-Smith (2006) and Hsu (2016). This course incorporated a variety of different field activities during the seven days in Hawaii, making the participants' learning of pedagogical knowledge and skills multi-faceted, and helped to maximize learning opportunities.

Provoked Interest

Another important finding of the study is that the participants' interest in teaching and learning more about biology was provoked. During the visit to Kewalo Marine Lab, the scientists there spoke to participants on various topics pertinent to marine biology. The participants commented that the lectures given by the scientists really helped them "better understand symbiosis" and they really enjoyed "hearing these scientists describe their research in person." One of the scientists' lecture on marine invertebrate animals and on what exactly causes the invertebrate larvae to undergo metamorphosis, piqued the interest of several participants to learn more about the topic; as one participant put, "[t]hat is something that I have never really put much thought into, but now I would love learning even more about it. I can understand how this subject field is so fascinating to Dr. H." Another participant admitted that this trip "revealed" her "inner interest in biology and environmental studies." Such provoked interest was also found in other studies (Bonderup Dohn, 2011; Cha, 2001; Bell et al., 2009) and in Dawborn-Gundlach et al. (2017), in which interest in Earth Science was aroused and the participants learned to identify links to other science areas.

Recommendations and Conclusions

The current study investigated the impact of a new interdisciplinary, hybrid design for field trips framed by a Study USA course. Based on analysis of qualitative data, this study found that the participants acquired in-depth biological content and experiential knowledge, practical pedagogical knowledge and skills, and a kindled interest in learning more about biology. Findings from this study support the use of such innovative hybrid field trips to enhance the learning and training of teacher candidates those practitioners and policy makers should consider towards improving pre-service teacher education.

Prior to embarking on the trip, participants indicated substantial anxiety in taking part in the course due to a real lack of background content knowledge in biology. However, the analysis of the data revealed that both pre-trip lectures/orientation, required readings, and pairings with a biology course partner were important in bridging content knowledge gaps sufficiently to enable participants to engage in the field course science activities and to make further gains in acquiring more advanced content knowledge. Active participation in field sampling trips and subsequent lab work, along with visits to the scientist labs and personal interactions with various domain experts contributed collectively to in-depth gains in content knowledge and pedagogical skills related to the teaching of biology, as well as heightened confidence that biology is accessible. Such gains in confidence may be beneficial towards counteracting stereotype or imposter syndrome threats of pre-service teachers of STEM, particularly of women who are prone to institutional biases that discourage participation (Lindemann, Britton & Zundl, 2016).

Throughout the course experience, participants were constantly engaged in active learning. In addition to gaining common types of content knowledge and pedagogical skills, the participants also acquired much more profound insights into both content and pedagogy, as well as into life habits, motivations, and perspectives. What participants learned exceeded their own expectations. Such learning outcomes might not have been obtainable in traditional learning environments. Thus, it would be wise for practitioners and policy makers to consider how to incorporate diverse active learning strategies in their design of field trips and in traditional learning environments, and to consider the impact on learning outcomes of a hybrid approach with a mixed discipline participant cohort. Moreover, the combination of traditional in-class experiences prior to and in conjunction with a suite of field trip experiences can enhance educational effectiveness, a model that should be kept in mind by practitioners and course designers of STEM education.

To conclude, a well-designed, innovative, intensive, and multi-faceted field trip experience has the potential of transforming teacher candidates into effective teaching professionals who are not only competent and confident in relevant STEM content but also in non-traditional, research-based pedagogical skills. More importantly, such field trip experiences can empower and equip teacher candidates with insights and inspiration for teaching and life-long learning.

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