

Science-Based Service-Learning in Science Teacher Education

Meghan Marrero
Mercy College

Abstract

Service-learning is a teaching practice in which students engage in community service that is relevant to their course goals and has been shown to improve students' achievement, attitudes, and application of course content. While there have been many studies on service-learning in teacher education, and the experiences have been very positive for teachers (e.g., for working with multicultural populations), few of the service-opportunities have been science-based. This qualitative case study examined two science education students engaged in an intensive service-learning experience, working with scientists on wetlands restoration. The study uncovered the ways in which the intensive service-learning experience influenced the teachers' practice. Through analysis of varied data sources, including interviews, blog posts, and classroom artifacts, findings suggest that the experience affected how the science teachers conceptualized ideas about science practices and the nature of science, and that the teachers used their experience in their instruction. Science-based service-learning may be a way to assist science teachers in developing their pedagogical content knowledge and ideas about science practices and the nature of science.

Keywords: service-learning, science practices, science teacher education, SSI

Service-learning has been touted as an effective instructional practice at the undergraduate level and in teacher education programs, leading to increased content knowledge, critical thinking, empathy, and cultural competence (Anderson, Swick, & Yff, 2001; Bringle & Hatcher, 1996; Calabrese Barton, 2010; MacFall, 2012; Mullis, Martin, Kennedy, & Foy, 2007; Zollman, 2012). However, there has not been a focus on the implications of science educators participating in service-learning opportunities that are scientifically-based, supporting field scientists. This case study examined the perspectives of two science teachers engaged in a science-based service learning experience, and it sought to uncover how the experience would affect their professional practice.

Review of Related Literature

Service-Learning

Service-learning, briefly described as a teaching method that meaningfully blends classroom experiences with relevant community service, has been shown to have profound impacts on new teachers, faculty, undergraduate, and graduate students (Anderson et al., 2001; A. M. Buchanan, 2002; Eyler, Giles, Stenson, & Gray, 2001). The term "service-learning" appears in many contexts and describes a variety of

activities, including internships and co-ops, volunteerism. However, service-learning is more specific than a volunteer activity in that it is closely tied to course/programmatic work and intended to help students, "gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility" (Bringle & Hatcher, 1996). Service-learning should include ample opportunity for directed reflection related to course learning and discussion with other students and the teacher or professor. Service-learning can improve self-efficacy, leadership ability, and communication skills. Service-learning also can increase students' sense of social responsibility, and result in a commitment to service. Incorporation of service-learning in courses also may result in academic gains, including improved application of content and analytical thinking as well as stronger sense of connection to their college (Mullis et al., 2007). Service-learning in teacher education has been lauded as a way to prepare teachers to implement the strategy in their own classrooms, to enhance their ability to reflect critically on teaching methods, and to develop more service-oriented dispositions (Anderson et al., 2001; Eyler et al., 2001).

There have numerous studies of undergraduate

science service-learning. In the field of environmental science, service-learning can improve awareness of and attitudes toward environmental issues, student motivation, positive environmental worldviews, personal environmental decision-making, and feelings of control (Cone, 2012). Eight years after participation in one service-learning activity, students reflected that their participation led to a better “real world” understanding of environmental issues and bolstered sense of environmental responsibility (Cawthorn, Leege, & Congdon, 2011; MacFall, 2012; Phillipson-Mower & Adams, 2010; Schellner, 2008). In other science courses, service-learning can improve course content knowledge. For example, undergraduate students who engaged in a stream water-quality monitoring project demonstrated improved assessment scores as compared to students in the same course in earlier years who did not participate in this type of learning (MacFall, 2012).

Most service-learning opportunities for education students are related to tutoring and/or mentoring students in high-need schools and communities. The goals of these experiences often include improving prospective teachers’ cultural competence or improving pedagogical skills and have been shown to be quite successful both in the United States and internationally (Anderson et al., 2001; C. M. Buchanan, Correia, & Bleicher, 2010; Calabrese Barton, 2010; Carr, 2002; Cone, 2012; Kirtman, 2008; Lawrence & Butler, 2010; Miyazaki, 2012; Roberts, 2003; Zollman, 2012). Some of these studies are science-related. For instance, Lawrence and Butler (2010) report that their teacher candidates participated in a Family Science Night at a local elementary school, which they found enhanced the teachers’ understanding of how to work with families. In another study, pre-service teachers’ service-learning was shown to improve their self efficacy in teaching STEM content to diverse students (C. M. Buchanan et al., 2010). Similarly, when elementary pre-service teachers were asked to complete a service-learning project teaching reading and writing through science, there were positive outcomes for the teacher candidates, students, and cooperating teachers (Yang, Anderson, & Burke, 2014).

There have not been many studies of science teachers participating in scientifically based service-learning activities, and science teacher educators may then be missing an opportunity. Even in pure (not education-based) science and engineering courses

that incorporate service-learning, the service is often related to educating the public rather than the science or engineering itself. For instance, Lee (2012) studied the effects of her undergraduate pre-nursing students enrolled in a general chemistry course. These students tutored local high school students in chemistry, and showed more positive attitudes and self-efficacy toward chemistry as well as higher test scores in their course. Phillipson-Mower & Adams (2010) note that service-learning activities could help science teachers to explicitly address several areas of professional development standards, which assert that science teachers should be involved in opportunities for true scientific inquiry paired with reflection. The authors describe two successful examples of environmental-related service-learning in teacher education, yet only one of them is scientifically based—a water quality monitoring activity. The other case is a “train the trainer” activity in which teachers learn to hold a youth summit.

Engaging in Science Practices

“Doing science” is argued as one of the key components of scientific literacy (Hodson, 2006) and service-learning opportunities can be a way for pre- and in-service teachers to “do science.” Hodson (1998) explains that “doing science—engaging in and developing expertise in scientific inquiry and problem solving” (p. 191). Wong and Hodson (2008) note a deep disparity between how scientists practice science and how science practices are portrayed in K-12 science classrooms. The Next Generation Science Standards (NGSS), a new national initiative for K-12 science education, set forth science and engineering practices as one of the three dimensions. The NGSS are designed so that when students meet performance expectations, they are able to “use their understanding to investigate the natural world through the practices of science inquiry, or solve meaningful problems through the practices of engineering design (NGSS Lead States, 2013, Appendix F, p. 1)”.

The NGSS as well as the National Science Teachers Association (NSTA) Standards for Science Teacher Preparation stress an understanding of the Nature of Science (NOS). The Nature of Science, refers to “the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge,” (Abd-El-Khalick, Bell, & Lederman, 1998, p. 418).

NOS includes several major understandings about science, including that science is “based on or derived from observations of the natural world,” “involves human imagination and creativity,” “at least partially subjective,” and is “socially and culturally embedded” (Lederman & Lederman, 2004, p. 37). Research finds that teachers typically do not have a strong understanding of the Nature of Science (NOS), and in particular, scientific inquiry practices, and their naïve ideas about inquiry can be very resistant to change (Abd-El-Khalick & Lederman, 2000; Blanchard, Southerland, & Granger, 2009; Lederman, 1992; Schwartz, Lederman, & Crawford, 2004). Other teacher-scientist experiences (i.e., summer research programs and specialized research courses) have shown to improve teachers’ conceptions of scientific inquiry (Houseal, Abd-El-Khalick, & Destefano, 2014; Hughes, Molyneaux, & Dixon, 2012; Schwartz et al., 2004), and lead to more inquiry-based instruction in their classrooms (Blanchard et al., 2009). However, a review of the literature found mixed results in terms of changing teachers’ ideas of NOS (Sadler, Burgin, McKinney, & Ponjuan, 2010). Osborne (2014) argues that knowledge of scientific practices is critical to science teacher development, and that being able to engage students in such practices is an important competency.

Theoretical Framework

This study was conducted within theoretical frameworks of social constructivism and situated cognition. Within social constructivism, science teachers learn and construct knowledge as a part of community of learners. The teachers as learners shared their own experiences and ideas with one another as they build content and pedagogical knowledge; their perspectives became important starting points for learning (Richardson, 1997) and the engage together in experiential learning and reflection (van Driel, Beijaard, & Verloop, 2001). The oceanography course and the service-learning experience (see next section) in which the participants were engaged were influenced by this social constructivist view, as described by Abdal-Haqq (1998) who explains that it is important for teacher educators “engage students in interdisciplinary exploration, collaborative activity and field-based opportunities for experiential learning, reflection, and self-examination,” (n.p.). On the service-learning trip and in the oceanography course,

there were many opportunities for participants to work cooperatively, ask questions, and build ideas together.

The second framework was situated cognition, in which people learn through authentic participation. In this case, science teachers learned by working with scientists in the field. In this framework, learners participate in the practices of another group, first observing and then being involved in that community’s practices, using the tools and processes of the group and becoming a part of the group’s culture (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Scott, Asoko, & Leach, 2007). In this case, the participants worked in the field with scientists, assisting with several different aspects of their work. The participants first listened to and observed the scientists, learning about the larger goals and contexts of the projects. Then the participants used the same practices and tools of the scientists. For a short time, the participants engaged by being a part of the scientists’ community. Sadler (2009) asserts that situated cognition is an appropriate framework for students studying socio-scientific issues (SSI); in this case the participants were learning about issues such as subsidence and erosion, local SSI.

Method

Participants

Two science education graduate students (one in-service and one pre-service teacher) were invited to accompany a group of educators traveling from New York to Louisiana to volunteer in a wetlands recovery effort. Both students were enrolled in a graduate oceanography course focused on both content and pedagogy in the area of oceanography for science teachers. The students were enrolled in a graduate education program in a private college in the New York metropolitan area with a very diverse student enrollment. Broad goals of the trip included participating in wetlands restoration efforts, introducing educators to the environmental problems of southern Louisiana, and assisting educators in making connections to environmental issues back in New York. These student participants supported the scientists in a number of ways, with several facets of mitigation and restoration work. For instance, at greenhouses, the students repotted seedlings of marsh grasses and employed propagation techniques to support the growth of barrier island plants that were later

planted to prevent erosion. On another day, the participants traveled to and worked on a newly created ridge in the bayou. The ridge was built from dredged material that was removed to allow boat traffic, and is intended to serve as a mini barrier island, preventing erosion, providing habitat for neo-tropical birds, and refracting wave energy back out to sea. On the ridge, the students planted seedlings and small trees, and they assisted scientists who were beginning a controlled study to compare the growth of different plant species on the new ridge. In these and other activities, the students were “doing science” (Hodson, 1998) and engaging in science and engineering practices with the scientists, engaging in the “social nature of scientific work and knowledge” (Scott, Asoko, & Leach, 2007). The group (including the participants) engaged in activities for up to twelve hours a day for four days. For the two students, the trip can be considered service-learning because they were engaged in volunteer activities that were directly related to the studies for their oceanography course. The volunteer activities and interactions with scientists dovetailed with several course topics: wetlands, hurricanes, food webs, water quality, and erosion and deposition.

The scientists with whom the participants worked rely on volunteers to support their research and restoration work. Wetlands in Louisiana are being lost at a rate of about 75 km² per year (Williams, n.d.) or about a football field every 38 minutes (Louisiana State University, 2008), and mitigation activities simply cannot keep up with the loss. There are many reasons for the drastic reduction in the land area, including diversion of the Mississippi River and its channels, subsidence, hurricanes, rising sea levels, draining, erosion, and the natural cycle of geological changes.

The researcher co-led the trip, which was also attended by 12 other educator volunteers, who were not a part of this study. Students were selected based on their enthusiasm for and commitment to science teaching as demonstrated in graduate coursework. The students also were willing to participate in the trip over a school holiday period. In addition to contributing to all trip activities, the students agreed to participate in interviews about their experiences, reactions, and perceptions. Participants also agreed to complete blog posts and reflect on their experience through guided discussions. The students’ participation in the experience was funded through a small

grant from their college. This qualitative inquiry of two science teachers sought to uncover the following research question: How does engagement in an intensive science-based service-learning experience influence science teachers in terms of their professional practice?

Case Study Design

This qualitative case study examined the perspectives of two science education students/science teachers as they participated in and reflected on an intensive service-learning experience. Merriam (1998) explains “A case study design is employed to gain an in-depth understanding of the situation and meaning for those involved. The interest is in the process rather than outcomes . . . in discovery rather than confirmation” (p. 19). The case was drawn across two participants, who although very different personally, share commonalities. Both were students in the same oceanography course, took part in the service-learning experience, and teach in the same community. The two teachers represent the “bounded system” under study (Merriam, 1998). The case study highlights participants’ understanding of experiences using their own words. As the course professor and fellow participant on the trip, the researcher became a participant observer (Jorgensen, 1989) which allowed for a deeper understanding of the participants’ experiences and reflections.

Participants

The two participants were “purposefully selected.” Creswell (2003) explains that purposefully selecting participants or sites helps the researcher understand the problem and the research question. As stated previously, the two participants of this study were selected because they both were enrolled in a graduate oceanography course designed for science teachers, were able to participate in the service learning field experience, and were teaching in the same community.

Matt (all names are pseudonyms), a soft-spoken, small-in-stature man in his early 30’s is a relatively recent immigrant to the United States from the Philippines. He came to the United States to serve as a teacher in the high-need New York City schools after teaching for seven years in the Philippines. As an undergraduate in Asia, he studied in a biology education program, getting a general survey in biology

and earning his teaching certification. He also earned his Master's in general science teaching in the Philippines. Once in New York, he completed his Master's in teaching students with disabilities. Matt was teaching seventh-grade science at an underserved middle school in the Bronx at the time of the study and continues to work at the same school. He explained that teaching in the Philippines is very similar to teaching in the Bronx noting, "The curriculum is actually almost the same, however the levels are a discrepancy. For example, the eighth-grade topics here are sixth-grade topics there." He offered that the technology resources are much better in the United States, even in underfunded Bronx schools, but that "here you have to be creative, you have to be imaginative to motivate the students to learn. Down there [in the Philippines], the students are really motivated to learn because they don't have the resources; they are really poor . . . even though some students are poor here, the motivation is not the same . . ." Matt is a calm, dedicated teacher who speaks highly of his students. He seeks to create engaging, high-quality lessons and takes new requirements, e.g., implementing Common Core writing standards, in stride. Matt strives to reach every student, and states that the service-learning experience made him a better science teacher.

Lisa, a White female in her early twenties was pursuing her graduate degree through a specialized 5-year bachelor's/master's program when the service-learning trip took place. At the time of the trip, Lisa was engaged in a semester-long student teaching experience in an urban Bronx high school, taking three graduate courses, and working two part time jobs. She is extremely industrious and self-motivated. She is extremely passionate about her subject area. She has lived in the Bronx her entire life, and admits she is sheltered in terms of her understanding of the rest of the world. The service-learning trip was only the second time that Lisa had ever been on a plane. Lisa enjoys debating scientific issues, learning more about cutting-edge scientific problems and new discoveries, and often speaks about helping her students see the relevance of science. Once she earned her master's degree and state teaching certification, Lisa began teaching biology and earth science at a high-need high school in the Bronx. Teaching at a tough Bronx school with 99% minority students is not easy for a young, White woman, but Lisa cares deeply about her students and seems to get them excited

about science as evidenced by student work that she has shared.

Data Collection

The case study drew from several data sources, including field notes, participant-produced blog posts, classroom artifacts and interviews. Multiple data sources increase trustworthiness in qualitative findings, and lead to richer description of the inquiry (Creswell, 2003).

Field notes. The researcher noted key observations noted during the service-learning activities and follow-up interviews. Participants' reactions, key phrases, and notable body language were recorded at various stages throughout the study, including during the trip and following interviews. Merriam (1998) states the importance of field notes, writing, "Observations must be recorded in as much detail as possible to form the database for analysis." These notes also became an important opportunity for triangulation of data sources and confirmation of ideas found, for instance, in the interview transcripts.

Blog posts. Within a few weeks following the service-learning experience, the participants each wrote a blog post, which contributed to a larger blog documenting the trip and sharing the experience with other educators. The topic was left wide open, although each participant was asked to include a reflective component. These blog posts became a source of documentary evidence to examine with the interviews and other data sources. Merriam (Merriam, 1998) explains that "one of the greatest advantages in using documentary material is its stability. Unlike interviewing and observation, the presence of the investigator does not alter what is being studied. Documents are 'objective' sources of data compared to other forms."

Classroom artifacts. Both participants reported using ideas, content, and strategies learned on the trip extensively in their classroom. To support these claims, they were asked to share student work, lesson plans, and other artifacts. Some examples were shared with the researcher, specifically class PowerPoints, some student writing samples, and lesson plans. Classroom artifacts were collected twice, once three months after participation, and once at the end of the following school year (16-18 months following the trip).

Interviews. The researcher conducted a series of semi-structured interviews with the participants at several intervals—during the trip (near the beginning and near the end), and approximately one month, three months, and 16-18 months after the trip. The interviews were conversational in style, with some prescribed questions and some questions derived from the transcripts of previous interviews. The initial interview lasted about ten minutes; subsequent interviews took 20-30 minutes each. All were conducted in-person and transcribed by the researcher. During the trip, the interviews focused on what the participants hoped to learn/were learning, things that surprised them or that were interesting them, etc. Following the trip, the questions centered on classroom implementation of ideas, content, and strategies from the service-learning experience. In each interview, participants were asked to reflect on the most poignant aspects of the trip and how they thought about the trip. This question was particularly important at the 16-18 month interviews to see how the participants had internalized and considered their experience.

Timeline. The service-learning experience, data collection, and processes took place over a period of nearly two years. The timeline below outlines the major activities associated with the data collection

Early Spring 2012	Late Spring 2012	Fall 2013
-Service-learning Trip to Louisiana -Beginning of Trip Interview -Field Notes Recorded -End of Trip Interview -Interview One Month After Trip -Blog Posts	-Follow up Interviews (approximately three months after trip) -Field Notes Recorded -Collection of Lesson Plans and Classroom Artifacts -Member Checking	-Follow up Interviews (approximately 16-18 months after trip) -Field Notes Recorded -Collection of Lesson Plans and Classroom Artifacts -Member Checking -Peer Debriefing

of this study.

Data Analysis

Data from all sources were analyzed using the techniques of grounded theory analysis (Charmaz, 2000; Dey, 1993), in which transcripts, field notes, and other sources were examined line by line with notes recorded and ideas grouped together. Each piece of data was analyzed individually, and line-by-

line. The research made notes and the data sources were compared to others using constant comparison. Common ideas that were kept together as categories were uncovered and then linked as interrelationships discovered, open and axial coding (Creswell, 2007; Strauss & Corbin, 1990). Finally, codes were collapsed to create broader themes, for example, original ideas about how the teachers used the service-learning experience to teach science content and scientific practices were later collapsed into a broader theme of incorporation into classroom practice.

This type of inductive process is in-depth and purposeful and results in emergent themes that are meaningful across data sources. Using a variety of data sources and triangulating findings increases the trustworthiness of qualitative analysis. Other elements of rigor included member checking and prolonged engagement with participants (Guba & Lincoln, 1989). At each interview, the researcher referred back to analysis of data sources including previous interviews, blog posts and classroom artifacts, to verify findings with the participants. The researcher maintained prolonged engagement by remaining in contact and conducting interviews up to 18 months following the service-learning experience. Additionally, as the course professor and as a participant observer, the researcher acknowledges bias that may cloud findings. This issue is partially mitigated

by using the elements of rigor such as prolonged engagement, triangulation, and member checking.

The theoretical frameworks were evident throughout the data analysis. Both participants, in various data sources, noted the importance of constructing knowledge with other participants, both the educators and scientists. In a blog post, for example, Lisa noted, “I have learned so much from the other participants of the group. It was great to share this experience with people who shared the same passions as I. This included teaching students and taking an interest in the environment. I would have never thought in a million years I would be bird watching at 6AM, or going to different sites and having the other

constructing knowledge with other participants, both the educators and scientists. In a blog post, for example, Lisa noted, “I have learned so much from the other participants of the group. It was great to share this experience with people who shared the same passions as I. This included teaching students and taking an interest in the environment. I would have never thought in a million years I would be bird watching at 6AM, or going to different sites and having the other

participants call me over and ask me to share in their passion.” Both Matt and Lisa frequently acknowledged the importance of this experience working with scientists to assist with their work, and being able to observe and ask questions.

Findings

Two major themes emerged from the data analysis: 1) Importance of the experience with scientific practices; 2) Recognition of the sociocultural nature of science; and 3) Incorporation of content and strategies from the service-learning experience into classroom practice.

Theme 1 – Importance of Experience with Scientific Practices

Hodson (1998) explains the “doing science” is an integral component of science education. An important theme to emerge from the data sources was that the participants seemed to internalize the importance of their experience of “doing science,” or as described in the NGSS (2013), engaging in science and engineering practices. Across data sources, Matt and Lisa both reflected on their experience in helping field biologists with setting up a scientific study during the Louisiana trip. They described the way in which the scientists designed their experiment, in terms of treatment and control groups, the attention to detail, data recording, etc. Matt noted in his one-month interview, he had referred back to some of the work he did with the scientists, saying, “It was fruitful in that what I read in the books, I got to experience them in reality, in actuality.” He talked extensively about how he was interested in learning how the scientists came up with their ideas, planned out their studies, and enacted them. He was particularly engaged in the experiment he helped to set up out on the ridge, comparing treatments, e.g., with and without fertilizer and mineral supplements on the growth of plants meant to slow erosion. He noted, “one thing I saw was the actual process, scientific process, of conserving a natural habitat.” During his three-month interview he explained, “What we did out on the ridge, helping the scientists, it was the perfect example of the scientific method in action.” Matt devoted much of his blog post, which gave an overview of all of the major activities from the trip, on the experience helping one of the scientists set up the experiment, “Baseline data was gathered once all the plants were placed in the various test plots.

Statistics on height, leaf spread and stem width were recorded which will be used as a measure of growth and survival of the plants on the ridge for a year.”

At the 18-month interview, Matt explained that his experience made him think more about science practices and how scientists actually conduct their investigations. “Well, scientific method, it taught me the process—how scientists use the scientific method in reality, not just in training.” He noted that in his experiences on the service-learning trip, he saw science practices take on different forms, sometimes more experimental, and other times more observational. He described how the scientists taught him that:

Basically you start by observing your surroundings, asking questions, formulating—what do you want to know about your surroundings? If you found something that’s interesting, you can start working on it, for your experiment.

Matt was referring to the scientists’ description of how they generated the experiment out on the ridge. The scientists observed plants and barrier islands in the area, and tried to hypothesize which plants would take root and result in more stable soil on a newly created island. These scientists did both observational and experimental studies.

In the same interview, Matt was asked to reflect on the most important aspect of the trip for him, either personally or professionally. He responded that the work of “doing science” had affected his teaching and that working as a scientist helped his learning. He felt that the experience helped him to better understand how science can be conducted in the field:

The exposure to the conservation—when we did the planting on the barrier island, I think that’s the most important thing that happened to me as an educator. First, I felt like I was working like a scientist. It really provided me with hands-on experience about the scientific method.

Also in the same interview, Matt also shared that he thinks about the nature of science and the idea of science practices differently in his teaching.

It made me more reflective on my practice as a teacher. Am I really a science teacher? Am I really systematic and basing everything I teach to my students on evidence,

because it's a big thing right now in schools, claims and evidence. So it made me more reflective about how I teach, how I deliver information—do all of my information have scientific evidence or backgrounds? That's one thing that I learned from working with scientists, real scientists.

Lisa's comments were similar. She also identified working with the scientists out on the ridge as the most critical experience of the service-learning trip. She discussed improving her understanding of oceanography course content, particularly in the topics of wetlands, erosion, and botany, but felt that the most important thing she learned was related to science practices. In the interview three months following the trip, Lisa reflected positively on her experience assisting the scientists, saying, “. . . digging holes for scientific research . . . it really made me understand the work that they do and how it applies to the scientific method.” Through service-learning with scientists, Lisa realized she had much more authentic experiences than what she had done in other courses. In her one-month interview, Lisa explained that in other courses, “The closest I had to hands-on [experiences] was, like, a pig dissection.” While she took many science courses as an undergraduate and felt that her understanding of scientific inquiry and biology content was strong, she found being in the field with “real scientists” to be very different. This experience, she said, “It made me appreciate it so much more, what the scientists are doing, with all this research.”

Theme 2 – Recognition of the Sociocultural Nature of Science

Science teachers often struggle with their own conceptions of the Nature of Science, and also how to teach it (Abd-El-Khalick et al., 1998; Abd-El-Khalick & Lederman, 2000; Lederman, 1992). There are many aspects of this epistemological idea, one of which is the idea that science is socially and culturally embedded, that is, that science is performed within a larger, related cultural context. One theme that emerged across data sources is that the participants noted how the scientific work was closely tied to the community and culture of the area.

For instance, Matt discussed the idea that the scientists' work was critical in their communities. He saw the need for the scientific investigations as they

related to local problems including erosion, subsidence, and other land-use issues. He saw the relevance of the work beyond Louisiana. He explained that prior to the service-learning experience:

I didn't know the effect of Southern Louisiana on the United States as a whole. It was actually an eye-opener for me. . . . I saw the importance of maintaining that ridge, of preventing habitat loss, preventing the tidal surge with the roots of the plants.

Matt's service to a South Louisiana community in need, supporting directly relevant work, was important to him. He stressed the importance of his service-learning in terms of highlighting socioscientific issues. He noted the responses to the “massive coastal erosion” and the “BP oil spill” and the “canal-building in the bayou” and “land subsidence” as issues that became more relevant through his service-learning.

Lisa seemed surprised that the scientists' work was so critical to their communities, particularly in response to Hurricanes Katrina and Rita (which had happened seven years prior to this service-learning trip). In her blog post, Lisa wrote

It was a pleasure helping the scientists in Louisiana further their research. Being right in the middle of the research really showed me how hard these people are working to save the environment as well as their homes. It is very uncomfortable to see the high waters along the roadside. These people are working hard to save Louisiana. Labor and assistance from volunteers really helps the cause. . . . I never realized the alarming rate Louisiana is sinking until I saw how high the water was in relation to the roads and the other various land masses.

From this experience, Lisa seemed to internalize the sociocultural nature of scientific inquiry. While traveling from site to site, Lisa remarked several times about how high the water levels were in relation to the road and people's houses, and mentioned that she was surprised at the scientists' discussions of how they communicated their work with the community through forums and neighborhood association meetings (field notes). She discussed that in her undergraduate studies, Lisa viewed science in a decontextualized, fragmented way. In her 16-month interview, she stressed that her trip made her think more about

the socially embedded nature of science and talk explicitly with her students about it. She said, “I explained that this was the scientists’ home area. They were studying what was important—they can’t just leave their homes [due to flooding or land loss].”

Theme 3 – Incorporating Content and Strategies into the Classroom

In their interviews during the trip, both Lisa and Matt identified sharing the experience with their students as one of the major reasons that they had agreed to participate. As they designed and enacted their classroom lessons in the time following their trip, both Matt and Lisa incorporated several examples of content and strategies learned through service-learning. They both shared that by giving their students a real-life context for science content and practices, they felt that students were more engaged and saw the content as more relevant. Additionally, both teachers incorporated some aspect of service-learning into their curricula.

Science practices. Both participants used their service-learning experience as an example when teaching students about science practices. Matt described ideas for adapting field activities for his classroom context. He developed a lesson that simulated the scientific study with which he assisted the field biologists. His students grew plants using different treatments in sand trays, making connections to wetlands and preventing erosion (lesson plan and photographs from the classroom). He described this activity in his one-month interview, saying:

I can use these trays, in my classroom, which I can do similar investigations, like to see which factors affect the growth of the plants, which plant will hold the most number of soil to prevent erosion. Of course, like, what we did in the ridge. It’s the scientific method. It’s the perfect lesson to explain to the students, to show them the application of the scientific method.

Eighteen months after the trip, he noted in an interview: Right now we are actually discussing it with my class, the scientific method, and I showed them pictures of what we did in Louisiana so that they see the objectives of the scientists and the basic stuff, the steps of the scientific method. So basically, you start with observing your surroundings, asking ques-

tions about your surroundings, formulating what you want to know. And then from there, if you found something that’s interesting, you can start working on that, making your experiment.

Lisa incorporated the same experience into her curriculum. She explained, “When I was teaching independent and dependent variables, I actually used that [the scientific experiment] as an example” (16 month interview). She described how she showed pictures and explained to students how she had helped the scientists prepare an experimental study in the field (PowerPoint from Lisa’s class). Lisa had students analyze and interpret the data from pictures and consider the research design of the scientists in Louisiana (lesson plan).

Science content. Both teachers brought science content from the trip into their classrooms. By the end of the trip, Lisa planned to use what she learned in her student teaching placement, stating:

I have an ecology lesson coming up, and I’m totally bringing this into my ecology lesson, I’m totally letting know about the experience and why they should learn about this stuff. Students learn things that pertain to their everyday life. This is very pertinent, especially since it’s happening right near us, and they probably don’t even know about it.

Throughout the study, Lisa frequently incorporated her service-learning experience into lesson plans. For instance, she assigned the students in her environmental science course a project in which they studied different regions of the country, and based on environmental, climatological, and geologic factors, determined where they would want to live. In her 16-month interview, she explained, “I used my Louisiana experience as an example of what they would have to do for the assignment.” She walked the researcher through the lesson plan and accompanying PowerPoint, which discussed the agriculture, hurricanes, low oxygen conditions, facing South Louisiana and the rest of the region, and things being done to prevent land loss and protect against hurricanes.

Lisa discussed how she used the story of her trip as a way to engage students and “open up” to them. She felt that by sharing this experience, her

students got to know her as a person and felt more connected to her experience and also the content she wanted them to learn. Her PowerPoints for this unit included her own personal photographs from the trip and connections to how scientists engage in their practices. The PowerPoint showed images of scientists in the field, and Lisa explained that she talked through for her students some of the studies in which she herself had engaged.

Lisa also made it clear that her authentic experiences made her more comfortable with content beyond her license area of biology. In her 16-month interview, she discussed that she had to teach an Earth Science course and that initially had been nervous about the content:

So, I'm very much a bio geek, I absolutely love science, but I'm not so connected with Earth science or environmental science as much. I'm just not into that part. I like to talk about the human body, and viruses and bacteria. I really don't think about that—put my attention to that stuff, but I after this I was really comfortable talking about Earth science . . . with the weathering, the erosion and other topics.

Lisa attributed her comfort level to hearing about these topics first-hand from scientists and helping them with things such as erosion prevention by planting seedlings out on the ridge.

Soon after the trip, in the one-month interview, Matt shared specific curricular topics that he felt were most relevant to his experiences in Louisiana, saying

There are topics in 7th grade science, like soil conservation, and air pollution, water pollution, basically I wanted to gain experience and share with them what I learned. I want to somehow plan similar activities to what we did in the classroom setting . . . also the different ecosystems. While we were at LUMCON, we talked about the importance of different marshland ecosystems, the marine communities, the hypoxic zones, the things that the scientists are working on to prevent these hypoxic zones.

Matt initially did seem hesitant, however, about sharing his experience with his students. He explained that he thought it would be difficult to make his trip to South Louisiana relevant to kids in the Bronx, saying:

Honestly, it is so hard for me to bring this back to this community because I live in an urban area. But given a chance to explore . . . Long Island Sound, that area, I think it will be more meaningful for me if I have other opportunities to bring my students there. I would want them to see the importance of these areas, these ecosystems. Second, I would introduce them to the conservation efforts in both Louisiana in NYS. Why are we doing this? And what's the importance of this for the present and future populations.

Matt did end up using his experiences in his teaching. Like Lisa, he felt that the service-learning experience enhanced his content knowledge as it related to his curriculum. Matt explained that after the service-learning trip and oceanography course, he ended up incorporating many more ocean-based examples of science content into his curriculum. Matt shared lesson plans about estuaries, watersheds and water quality with the researcher, which illustrated examples and ideas from his experience in Louisiana. Matt also shared that he strove for his students to become more conservation-minded and see why their actions and studies were important, noting, "For example, when I plant this species of plant . . . somehow when this plant grows, it can lessen the amount of carbon dioxide in the air. In the long run it will give good results."

Matt made connections to Louisiana after Superstorm Sandy hit New York City in 2012. He explained,

after Hurricane Sandy, we did get the chance to talk about the importance of barrier islands so from all the from Massachusetts all the way down to New Jersey, we traced the barrier islands what are the issues facing . . . their importance, ecological importance and . . . I used Google Earth to show them over here and, over there [South Louisiana]. I showed them the projected loss . . . if people will not act in saving these wetlands or the estuaries.

He reflected that being in South Louisiana and working with the scientists had helped him to better understand the importance of wetland, and thus be able to share this with his middle school students.

Service-learning. Matt stressed the importance of getting students into the field to have experiences similar to his own. At his one-month interview, He explained,

I will start small scale. Perhaps we can do a community clean up surrounding my school first. And, after that, we can go to the Bronx River and do a small study, a water sampling study or an organisms count, a species count there. And from there, if we have enough funds, if we have, I can bring my students by the East River or work with organizations. . . . Somehow these activities will motivate them to become scientifically inclined persons in the future. If they have experience in cleaning the environment, conserving the environment. . . .

Matt felt that involving students was really important for conservation to be relevant in an urban community. Matt wanted students to volunteer and feel what it was like to make a difference, noting, “These simple little acts can actually affect the ecological community.” Matt elaborated, emphasizing how service learning could deepen his students’ understanding:

Everything they do has an effect on the environment. Because in that way [through service learning], these positive experiences will make them more aware of conservation efforts, conservation biology, and the importance of other organisms. We are part of an ecosystem. You remember it forever.

At the 18-month interview, Matt had put some of his plans into action. He engaged his students in a campus debris survey. In this activity, students picked up garbage from their school campus and took data on the types of refuse that they find. They related their findings to International Coastal Cleanup efforts in surveying marine debris on beaches, and made connections to the idea that we are all connected to the ocean through watersheds. Matt viewed his students’ experience with the campus debris survey as a scientifically-based service-learning experience similar to his own. He felt that students were better able to apply their scientific practices, e.g., interpreting their data in a bar graph, through an authentic scientific experience. Matt also discussed future plans for increasing his students’ involvement in service-learning. As a follow-up to the service-learning trip, the trip leaders introduced the educators to

variety of scientific groups back in New York doing studies with the help of volunteers. Matt mentioned that he wanted to become involved with some of these efforts. He explained:

I spoke with my principal and asked her if I could go down to the Bronx River and do some studies of the water quality. That’s one of my plans in the future. And, if we have funds, I might bring my students to the Long Island Sound for water testing, or we can do collection of living things there, to use the microscopes and do invertebrate studies.

Lisa also tried to incorporate service-learning into her curriculum. In her interview 16 months after the Louisiana trip, she explained that she made connections with scientists and rangers at a local park but was disappointed that only a few students got involved.

I tried to do that. I invited a ranger guy to come to my classroom . . . He came and talked to them and then the kids went out to look for evidence of coyotes—but very few kids did it. They had to go there . . . dig up feces, put night cameras up, etc. . . . if I had a more dedicated group of students . . . I would love to do something more like that . . .

Both Lisa and Matt explained that the science-based service-learning experience had been very important and powerful for them, so they wanted their own middle and high school students to have similar experiences.

Developing Pedagogical Content Knowledge

These ideas are all aspects of the teachers’ pedagogical content knowledge (PCK) in science teaching. That is, the service-learning experience enhanced their PCK, providing them with new “. . . powerful analogies, illustrations, examples, explanations, and demonstrations . . . that make it [the subject matter] comprehensible to others” (Shulman, 1986, p. 9). These teachers used their experience in several different ways—to connect to students, as examples for teaching both science practices and content, and as an instructional method, getting students involved in service-learning. As Lisa said in her 16-month interview of her classroom lessons, “I used what I knew best, my Louisiana trip, as an example.” Matt

said, "I realized that it's even more effective to teach something if you have a first hand experience with that particular thing. I learned that grasses play a very important role in conservation of these areas."

Discussion, Implications, and Next Steps

This study examined science teachers' reflections on a scientifically-based service-learning experience through a variety of data sources, including interviews, blog posts, classroom artifacts, and field notes. The findings suggest that engaging in these types of activities may give teachers experience "doing science" as well as provide new, relevant contexts and strategies for use in the classroom to improve student engagement and connections to the science and engineering practices (NGSS Lead States, 2013).

The findings of this study of science teachers are similar to other studies in which students gained a better understanding of what scientists do (Lea & Urguhart, 2010; MacFall, 2012) and felt more confident in engaging in scientific practices (Gorman, 2010). The implication of this finding as it relates to science teaching, however, is important. Hodson (1998) discusses the idea that science is often misrepresented in K-12 schools. Science curricula promote myths, such as, the idea that science is only experimental, that it is a set procedure, that experiments are absolute. He notes that many science teachers perpetuate misunderstandings about the nature of science and how scientists "do science." One aim of the eight Science and Engineering Practices of the Next Generation Science Standards (NGSS) is to help students to think scientifically, such as through the practice Analyzing and Interpreting Data (NGSS Lead States, 2013). Scientifically based service-learning may be one avenue to allow teachers to experience science and engineering practices in a rewarding, practical, and participatory way.

In terms of the teachers' views of NOS, more study is needed. Schwartz, et. al (2004) note that "General agreement within the current postmodern view acknowledges science as a human endeavor, directed by theory and culture, reliant on empirical observation, and subject to change." Based on the findings of the present study, a scientifically-based service-learning experience such as this could be an opportunity to provide relevant experience with tenets of the NOS, including idea that science is socioculturally embedded and that there is not one ab-

solute scientific method. While this was not an initial goal of this study, these teachers began to recognize aspects of NOS, and this may be an area for further opportunity, especially since other studies have found that working with scientists does not necessarily change teachers' views of NOS (Sadler et al., 2010). The authors note that the simply "doing science" alone may not influence views on NOS, and that guided reflection may result in cognitive dissonance and conceptual change about NOS. Thus, it would be critical in future service-learning experiences for science teacher educators to be more explicit about the tenets of NOS and ask teachers to reflect critically on the tenets and how they are demonstrated and experienced through scientific service-learning projects. This could be an important future research direction.

The participants' comments across data sources suggest they are thinking more explicitly about how they convey the practices of science to students and engage them in those practices. At the same time, Matt still talked frequently about the "scientific method," presumably engrained from his own training. The Next Generation Science Standards (2013) explicitly try to get away from the idea that there is one scientific method and ask teachers instead to engage students in the science and engineering practices (NGSS Appendix F), and studies show that true inquiry and attention to NOS are not taking place in science classrooms (Capps & Crawford, 2013). Osborne (2014) writes that teacher educators must think about how to develop our candidates' PCK as it relates to engagement in the eight science and engineering practices. He urges us to consider our own work in science teacher preparation and understandings of the science engineering practices, and how we engage our teacher candidates in the practices as they prepare for the classroom. Other authors ask us to look at teacher candidates' scientifically-based experiences, and how we prepare teachers for teaching these new standards (Faber, Hardin, Klein-Gardner, & Benson, 2014). Given the new focus on these practices, science teacher educators might consider science-based service-learning activities as one avenue for furthering their candidates' experiences with the practices in authentic settings.

Another aspect of the research to study further is the importance of the service aspect of the experience. Why is it important that teachers are giving

their time for science-based causes and to participate in scientific research, while at the same time reflecting on course content? How do these experiences affect them as individuals and teachers, and how do they affect content knowledge and teaching practices? Is service-learning with scientists different from participating in a paid or credit-bearing research experience?

This small case study's findings are promising, as they suggest that science-based service-learning may be an effective way to engage science teachers in scientific practices, support them in developing their ideas on some aspects of NOS and assist them in developing their PCK. Further studies are certainly needed, but there are many scientists who would welcome the help of teachers and teacher candidates as they pursue their research studies.

Correspondence concerning this article should be addressed to Meghan Marrero.
mmarrero3@mercy.edu

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