

# Chapter 13

## Teaching with Citizen Science—It’s More than Just Putting Out Fires!

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Reformers in science education continue to stimulate thinking, debate, and changes in the way we conceptualize the preparation of science teachers, reflecting a shift in emphasis from teaching skills and strategies of teaching to providing conditions associated with prospective teachers’ increased responsibility for their own learning. Yet, as Northfield (1998) points out, for the most part, pre-service teacher preparation programs are designed to present what “science educators believe new teachers need to know and understand to work in the profession” (p. 695). Researchers such as Aikenhead (2006), Elmesky (2006), Maulucci (2008) and Tobin (2006) suggest the need for changes in the way that science teachers are prepared to meet the demands of diverse communities who are often at risk socially and environmentally. Not surprisingly, a half-century after Sputnik, these science educators, and others like them point to the failures of science teacher preparation to align with criteria such as relevance, interest and justice underlying many of the pervasive questions of equity in science education and schooling in general. Thus, it is imperative that schools and universities come together to understand the intent of education in the twenty-first century and create a new vision of science teacher preparation, in which prospective teachers examine the way their assumptions come to be formed, and not only solve problems but discover how they originate. We share one perspective on how change can be enacted by drawing from research conducted in a secondary science teacher preparation course organized around the tenets of citizen science.

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## **I've Seen Fire and I've Seen Rain**

The caravan of prospective science teachers heads out of town, driving towards the rural farmland where the university's environmental safety complex is located. After traveling through several twists and turns in the road, they soon see Lance,<sup>1</sup> one of their classmates, standing alongside the shoulder of the road in a brightly colored rain poncho directing traffic. Through the heavy rain, a small building with an oversized garage becomes visible, a structure surrounded by trees with few signs of civilization. This facility houses fire safety equipment, a building primarily used for training, repair and storage. The prospective teachers gather in a state-of-the-art presentation room for a brief introduction to fire safety. Quickly engaged, they pose many questions about the different types of fire extinguishers, home safety, and the use of equipment such as pressure cookers in the science lab. After sharing their own experiences with fire, they follow the training instructor to an outdoor area used for putting out fires. The rain is still falling as each prospective teacher, together with Morgan, their course instructor, brave the soggy ground to put out a fire, using some of the extinguishers they encountered earlier. Morgan later explained how the experience of working together in the rain to extinguish fires in an authentic context, was a good way to build relationships and a sense of community among the prospective teachers. In her excitement, Rose, one of the prospective teachers, shared how the experience of actually using equipment to extinguish a fire was invaluable, providing her with the confidence and a level of comfort needed to incorporate investigations and labs in her future classroom.

The fire safety training at the environmental complex is typical of the kinds of experiences that serve as the basis for this "Methods"<sup>2</sup> course required for secondary science teacher certification. In contrast to a decontextualized set of skills and strategies that have too often characterized science teacher preparation, this course is designed to help the prospective teachers view science teaching and learning through the lens of ecojustice philosophy<sup>3</sup> with a specific emphasis on the pedagogy of citizen science.

## **Setting the Stage for Developing Philosophy**

Twelve males and eleven females enroll in the Methods of Science Teaching course, and like many students, enter the classroom on the first day with expectations based on the university catalogue description of the course as "science instructional strategies and classroom assessment for students in grades 7 through 12" (University Bulletin 2009), as well as the stories of previous students. Emma, with her strong chemistry background, knows how to run a lab, but is worried about her ability to manage students. Bernie expresses the desire to learn how to create an interesting curriculum which will be well timed and meet the diverse needs of students. Lynn, who notes that she is a good tutor, wants to make sure that she can meet the national

**Table 13.1** Identification of characters

<b>Participant</b>	<b>Description of role</b>
<i>Bernie</i>	Preservice teacher; chemistry background
<i>Houston</i>	Preservice teacher; biology background
<i>Lance</i>	Preservice teacher; chemistry background
<i>Morgan</i>	Professor; course instructor
<i>Patricia</i>	Arboretum faculty; co-educator
<i>Paul</i>	Preservice teacher; physics/chemistry background
<i>Rick</i>	Luna Farm manager; co-educator
<i>Rose</i>	Preservice teacher; biology background
<i>Sarah</i>	Preservice teacher; chemistry background

standards (Table 13.1). These students’ expectations stand in stark contrast to Morgan’s explanation of the course as an opportunity to develop a philosophy of teaching. Describing learning to teach as a philosophical process, Morgan explains the importance of a guiding philosophy in making decisions about the relevance of any new ideas introduced in the course and beyond. Rather than providing a specific set of methods or access to teaching strategies, he envisions that the prospective teachers will frame their understandings and make instructional decisions in light of a developing philosophy of ecojustice as the foci of the course.

## *Ecojustice*

Researchers such as Bowers (2001, 2002), Mueller (2008), Mueller and Bentley (2007) and Tippins et al. (2010) describe the multiple dimensions of ecojustice philosophy. They propose that ecojustice: (a) considers making the global more local; (b) encourages decision-making skills; (c) challenges cultural assumptions, and; (d) promotes an increased awareness of the use of language. The essence of ecojustice is the relationship between society and ecological awareness, preservation and sustainability. Sachs (1995) explains that ecojustice philosophy is concerned with environmental issues in a variety of social ways including equity in relation to nonwestern cultures, abuse of tribal groups through land exploitation, economic prosperity in conjunction with land use, and modifications to lifestyles in ways that benefit the environment. In the context of science teacher education, Britton (2011) and Tippins et al. (2010) maintain that ecojustice philosophy helps in creating democratic learning environments with learning a process, which is mediated to encourage participation by multiple parties. In this sense, for the prospective teachers, ecojustice philosophy opens the door to learning in dynamic contexts, which creates the potential for challenging assumptions deeply embedded in the belief systems of each student.

## Revealing the Characters

The prospective teachers in the aforementioned Methods of Science Teaching course internalize teaching science through a veneer of past experiences. For some, this façade develops into the grand narrative of school success and allows them to embrace a philosophy of ecojustice. They may develop a civic courageousness which enables them to speak out unabashed and with a moral position that leads to a generation of shared responsibility. Others are challenged to move beyond their comfort zones of measurable, standardized outcomes and unquestioning acceptance of “official” knowledge. In particular, we look more closely at the lives of two of these prospective teachers—Rose and Paul—for potential insights into how ecojustice fits within their changing conceptions of schooling.

### *Rose*

Rose grew up in a predominantly rural, Africa American community as a child of Mexican parents who worked in the fields. Her love for biology and environmental sciences is steeped in early experiences that fostered a respect for the Earth. Rose is the first in her family to obtain a college education; she emphasizes how her immigrant parents instilled in her a respect for education, family and independence. Rose frequently recalls the rich cultural heritage of Mexico where she spent many years of her life. Although an excellent student during her K-12 school years, Rose notes that early on in life she lacked confidence in her ability to succeed until she realized one day that whatever decisions she made about life it would all work out. Rose did not initially consider teaching as a possible career. It was a serendipitous opportunity to work with Pre-K children in an outdoor setting, and later employment at a local environmental education center, that nurtured her interest in the teaching profession. In her future teaching, Rose expresses the desire to diminish students’ fears about the natural world through direct experiences with nature and animals. She places little value in the memorization of isolated facts and information. Instead, she argues that it is more important to “make a difference, to share your passion with others and allow the enthusiasm you have for life to be evident in everything you do.” For Rose, teaching is about making a difference and leaving the world better off than how you find it. Throughout the course, Rose was challenged to consider how citizen science might support her goals within a science education context of increased accountability and standardization for teachers and students.

### *Paul*

Paul typically appears in class wearing a dark trench-coat with a thick novel clutched in his hand. A physics major, he hopes to one day instill a love for the subject in

his future students. Paul grew up as a Chinese-American in a home with parents and other family members who are quiet and reserved. His parents emphasize the importance of maintaining and sharing their Chinese cultural heritage, preferring to speak Mandarin in the home. As a result, Paul feels that it is very easy for him to accept individuals who express ideas different from the norm. As a child, Paul rode bikes with other children in the suburban neighborhood where he grew up, before video games became popular and “took” them inside. He had little experience with nature or pets during these formative years. Paul describes himself as a self-proclaimed recluse, noting “I don’t talk much to the people in class, I’d rather be alone.” He suggests that he is saner than most people, and enjoys reading books rather than social interactions. He discusses his unique fascination with what can be learned from books, considering them the ultimate source of knowledge. Although reflective and solitary, Paul is not afraid to speak up when he has strong opinions. He often mentions ideas that are directly at odds with his peers, but gracefully listens to their perspectives. Occasionally, Paul contributes to the class discussions by posing a thought-provoking or startling question, creating an excitement among his peers that is refreshing but disconcerting. Paul admits that his future students might consider his class to be uninteresting, given his preference for lectures and reading assignments. He questions whether he will be an effective teacher, explaining that his inability to “read” others might make him seem uncaring. Throughout the course, Paul struggled to create a vision of what citizen science or ecojustice might look like in his future teaching.

## **Citizen Science as a Context for Learning to Teach Science**

Implicit within the ideology of citizen science in teacher preparation is an emphasis on learning about the health of the local community, beyond the walls of the school. Citizen science has been traditionally characterized as a top-down approach featuring projects initiated by scientists who enlist community members to collect data on issues- with little immediate relevance to citizens’ lives. However, this *Methods of Teaching Science* course recast citizen science as a pedagogical approach consistent with justice, which results, by its very nature, in aims for democratizing science education. Morgan presents citizen science as more of a bottom-up approach intended to promote students’ interest in the community, the environment and lifelong learning. He wants the prospective teachers in the course to develop awareness and become informed about issues taking place in the local environment and construct knowledge that would ideally encourage them to seek ways of using science education to further the competencies and community involvement of their future students. As an innovative professor, Morgan clarifies his stance on citizen science as being about “becoming informed in a place, and learning what they (the prospective teachers) need to know so they can participate more fully in decision-making, policy-making and democratizing science.” Recognizing that the prospective

teachers are only transient members of the local college community, Morgan feels that by teaching ways to assess the health of communities through citizen science, the future teachers will develop tools that can be transferred throughout their lives. Some of the course activities, which were designed to increase the prospective teachers' understanding of citizen science include:

### ***Monarch Tagging***

Prospective teachers engage in an authentic experience with butterflies, learning about the science behind the *Monarch Watch Program* ([www.monarchparasites.org](http://www.monarchparasites.org)). They learn about monarch diseases and the role of citizens and scientists in determining health and migratory patterns. They observe examples of parasites in infected butterflies and discuss the ways they can engage students in collecting monarch data in their local communities and environments.

### ***Bee Hunt***

The Bee HUNT! research project ([www.discoverlife.org/bee](http://www.discoverlife.org/bee)) provides prospective teachers with an introduction to “citizen science”. In this project, students locate goldenrod plants and document insects that serve as pollinators. The project uses digital photography and media to aid in data collection. However, standardized equipment and protocols are used as a way of encouraging consistency for comparison of data across larger areas of the globe. While Morgan considers the Bee Hunt! project to be a more top-down approach to citizen science, he believes the experience will provide the prospective teachers a basis of comparison with more bottom-up approaches (note that Bee Hunt! does not consider itself a citizen science program, but an evolving authentic research context for volunteer involvement).

### ***The Back Yard Project***

The prospective teachers' involvement in the *Back Yard Project* (BYP) is the result of collaborative planning between Morgan and Patricia, a staff member at the Piedmont Arboretum. The BYP project places an emphasis on how local knowledge of plant, soil, water and air resources is expressed in the community and highlights how students can enact citizen science differently. Working in small groups, the prospective teachers design protocols and inquiry lessons for exploring different aspects of the ‘back yard’. One group creates a protocol and lesson for measuring trees and determining biodiversity. Another group focuses on water absorption and develops a citizen science rain garden project. In a reversal of traditional roles, the

prospective teachers become leaders when they share their ideas for citizen science projects in a workshop presentation for local teachers and other co-educators (the BYP project incorporates the teachers' lessons into a workshop, where the beginning teachers teach seasoned teachers about the local habitat).

### ***Mapping Your Community***

Using individually constructed maps of their neighborhoods, the prospective teachers analyze questions about the local community such as: How do people in this community obtain their food? What kind of access to transportation is available? Where are outdoor spaces located in the community? The 'mapping your community' activity lends itself to the development of other course activities, such as situated learning at Luna Farm.

### **Learning at Luna Farm**

Luna farm, a local cooperative or community supported agriculture project is situated about ten minutes from the university. It serves as the setting for a cool early November morning meeting for a first-hand experience with the local farming community. After parking in a muddy field, Morgan and the prospective teachers walk down a one-lane dirt road to an open area under a grand old oak. The early morning crowd appreciates the old farm house, talking about experiences they recall in other, similar places. Rick, the "caretaker" of the farm, joins the group with conversation about the types of crops, animals and farming practices that they could expect to see. He uses words like "pedagogy, action preferred and perennial truths"—in relation to education, science and the farm. The group starts down the dirt road, pine trees meeting the hardwoods lining the path. Stopping at an enclosure for a sow and her baby pigs, Rick cautions everyone to be careful so that they will not be shocked by the electric fence. Prospective teachers, some with great care and others with little concern, climb over the single strand of wire. The sow, having a relatively young set of babies, is lying on her side in a big pile of hay, under a shelter consisting of one solid back wall with four wooden posts holding up the tin roof. Rick discusses the age of the piglets, and Sarah whispers that her husband would say Rick was not a real farmer because he calls them piglets. Rick walks us up to the sow and describes the breed, the typical number of babies birthed each time, and the preparations needed to finish the hogs for distribution to restaurants. As the group of prospective teachers walks away, the baby pigs begin to nurse and one of the prospective teachers near the back asks 'why the babies butted against the bag so much.' Having grown up on a farm, I quietly explain my understanding.

As we move from the pig pen down the road, Houston shares a story with a small group of preservice teachers of how he and his grandfather used to castrate baby pigs. No one asks questions about that process! Rick directs us to meet at the chicken “tractors”—large rectangular frames enclosed in chicken wire with half also covered in plastic tarps. The “tracts” had handles on either end for ease in movement. Rick describes how the boxes are repositioned at least once a day for the chickens to feed on grubs and bugs found on the ground and in left behind cow waste. Rick also explains how at least 25 % of the chicken’s food comes through what they eat from the ground. He elaborates, explaining how this type of feeding is close to what it would be naturally, but with obvious dietary supplements. As we stand on a hill overlooking much of the farm, Morgan asks why the chickens over on the trucks are white and why the others are brown or guineas (grey). Rick talks about the many different breeds of chicken that exist.



Eventually, the group walks down a small hill towards the tree line to reach the garden plots. Rick asks the prospective teachers for their ideas about the garden’s location. Some suggest that it needs to be at the bottom of the hill for easy access to water; others hypothesize that it is because of the nutrients that are found along the creek. Rick agrees with them about the nutrients but talks about the drought and the effect of flooding on erosion at the farm.

Rather than dividing the prospective teachers into groups as was originally planned, Rick has the entire class move up near the truck to break apart garlic bulbs into cloves. Rick explains the purpose of *Allium* (family in which garlic is found), and asks for other examples in the same family. He explains, ‘Garlic is a great pest control plant and way of adding nutrients to the soil—it’s very cleansing.’ Lee is curious about whether garlic ends up being a clone of itself, since the larger bulbs are separated into cloves for planting. Rick acknowledges it as a



good question, but is unable to answer it. Everyone gathers around the farm truck with boxes of garlic bulbs, laughing and talking with each other about recipes and their use of garlic; a real sense of community seems to have developed over the semester and is evident in the interactions today. Rick's instructions on how to plant the separated cloves consists of asking students about how deep they should be planted and in what direction. After some instruction, the students are sent down the row in different directions to begin planting. Some work in groups of three-four to make holes in the ground, planting and covering the garlic in an assembly line fashion. Others work alone in their own world of dirt, cold air, and garlic. Some of the prospective teachers are very organized in their planting methods—Houston is very methodic as he pokes holes and stuffs in the garlic; after he finished a section of about three feet of poking holes and planting garlic, he moves back to cover the holes. Rose works across from him using the same process. It is a great bonding opportunity as everyone share the experience of getting dirty planting, laughing and taking pictures. When the last clove drops, I look up to see Bernie over to the side, wiping his hands in the grass. I ask what he is doing, and he responds, "cleaning my hands." I laugh and say, "that is what your jeans are for." He is very serious and solemn when he responds, "not these jeans." We laugh at him because he also is wearing a white sweatshirt with no dirt on it, after planting garlic in the thick, red clay.

The prospective teachers hold different understandings of the value in visiting Luna farm, and what they are expected to learn from the experience. The unique perspectives of the prospective teachers support the integration of this experience as a potentially pivotal learning event, while encouraging dialogue about shared knowledge. Evidenced in this story are the varied responses and memories held by each of the participants, reflecting an awareness of their surroundings on a deeper level than simply participation. Some, like Sarah, think it is a good experience, for those unfamiliar with farming, relating it to the current organic movement and suggesting that it can foster a better understanding of food production. Bernie, who has very limited farm experience, expresses his enthusiasm at seeing baby pigs and planting garlic, noting that the farm is a great place for showing students the relevance of science and fostering curiosity through questioning. While Paul recognizes the value of learning about the farm as a community resource, he struggles to connect the experience with any kind of instructional value for the physics classroom.

## **Embodied Learning**

Teacher preparation courses often leave little room for beginning teachers to take responsibility for their own education in ways that develop their capacity to ask questions, challenge, make decisions and solve problems collectively. Throughout this course, however, the prospective teachers have continual opportunities to consider ecojustice philosophy and its' pedagogy of citizen science, amend the 'soils of

philosophy,' and make their own decisions regarding its relevance to teaching and learning. Admittedly, Morgan does not expect all of these prospective teachers to accept and value an ecojustice ethic, explaining: "It takes time but I think a few usually get it (ecojustice philosophy) by the end, and a few more get the whole idea of citizen science, which works toward ecojustice." For many of the beginning teachers, learning to teach science with ecojustice in mind is an unfamiliar experience. Faced with the more holistic approach of ecojustice-oriented teaching, learning, and curriculum, the prospective teachers often find themselves outside their personal comfort zones. This is certainly the case for those few individuals, such as Paul, who with a physics or chemistry concentration think about ecojustice as pH values or energy in an ecosystem—something that relates but is different than the way they experience learning. Learning to teach through embodied experiences involves an integrated way of knowing, embedded in a community of practice. The vast majority of the students in the class, having biology concentrations, share natural ways of negotiating meaning about what matters, what to pay attention to, and what to ignore. It is not surprising that the three prospective teachers with physics or chemistry backgrounds, already set apart from the stories, routines, and ways of doing things common within the biology community, initially find it very difficult to navigate meanings in citizen science and likewise envision how they might integrate it in their respective subjects. Conversely, Rose, with her biology background, responds to the complaints of her peers about participating in outdoor activities during the midst of a rainstorm; holding an umbrella, she says, "it won't kill them." Rose values this type of experience because it allows her to see the true expressions of nature, be *within* an experience, and be encouraged to view that experience through both an insider and outsider perspective. For Rose, learning in the rain is truly an embodied shared experience, since she takes in the sounds, smells, complaints, and content which is visibly present while attempting to negotiate how she might incorporate these ideas in her future teaching.

The Fire Training, BYP workshop and visit to the Luna Farm are just a few examples of the many embodied learning experiences in the course. Stelter (2004) notes that, on a personal level, "meaning evolves by embodying the world, by relating oneself actively to the context, and by understanding and reflecting on the situation through a situated action" (p. 7). In other words, for Morgan, there is an inherent tension of trying to be attentive to the primary content his colleagues will hold him accountable for covering, while at the same time, removing the learner from a context that stymies to ideally encourage learning at a deeper level. Barab et al. (2007) describe the challenge of combining both content and context in ways that allow individuals to remain in the embodied experience. An integral part of the course is the emphasis on negotiating or co-constructing the meaning of ecojustice, and by extension citizen science, through participation in a community of practice. Morgan, albeit the professor for this particular course, is only one of many co-educators invited to actively participate in the class sessions. Ecologists, botanists, entomologists, farmers, science education graduate students and many other individuals comprise the course, and encourage the prospective teachers to ask questions and make sense of their encounters with citizen science, in light of

their personal and professional interests. The semester is constructed of shared experiences; traveling for a weekend camping trip, taking hikes at the arboretum, and writing in nature journals while sitting on a basaltic rock outcrop, all contribute to the development of a community of practice. But more than any single activity, embodied learning is captured in the narratives and stories woven together in the process of planting garlic, extinguishing fires in the rain and teaching teachers how to design citizen science projects for their own classrooms. True to the tenets of citizen science are the ideas of participation and the existence of multiple knowledge holders, which are represented in the collaborations with co-educators (students included). Roth and Lee (2004) highlight the role of collaborators in their work as well and discuss the idea of embodied learning in science education, acknowledging the legitimacy of stakeholders in the community, and emphasizing the value of living what is studied.

### **Embodied Learning as an Impetus for Ecojustice Philosophy**

Barton (2009) shares her belief that learning is about “deciding who you are, what you want to be, and actively engaging to become part of the relevant community” (p. 415). She also suggests that “knowing” is about connections between the socio-cultural, material, and natural world “that give form to being.” Learning in this way is a process of becoming something, a transformation that may entail qualities of what you are but also one that allows for the integration of new ideas, as a result of being and wholly taking part in the experience. Written as a feminist epistemology, Barton’s (2009) discussion of embodied learning is especially relevant to the course focus around ecojustice philosophy. The positioning of nature-as-both-a-context-and-co-educator as well allows the prospective teachers to develop emotional, intellectual and physical connections to what otherwise may have been taken for granted. Though the prospective teachers are situated within embodied experiences, it is not at the level described by Barton, where the need for action or varying levels of advocacy generate a sense of embodied responsibility. Nevertheless, the experiences included in the course help plant the seeds, which may even sprout, given the likelihood that the prospective teachers can integrate similar practices within their future classrooms, and consider the shared possibilities of getting engaged and involved in the communities where they will eventually teach.

Barton (2009) emphasizes the idea of counter knowledge as that which is held by individuals who are considered marginalized. She argues that this type of awareness truly represents embodied knowledge. Embodied experiences position an individual for becoming a stakeholder and defending a location, people or an idea. While the prospective teachers do not develop this level of advocacy through the course, it can be argued that without first-hand knowledge and experience there is a slim chance for understanding the basic need for action in the first place. One of the significant challenges for those who talk about embodied learning is that it focuses on a social context and entrance into a world that is often counter to any individual’s existing

knowledge if s/he doesn't reside within the community. Barton (2009) argues for counter knowledge as integral to embodied responsibility through her description of a seemingly ecojustice-based project. The example she provides involves a geologist who uncovers evidence of environmental toxins within a low income community. The knowledge this geologist reveals is presented to the community members who then takes action and become experts and decision-makers, influencing their own lives and local environment in the process. Not all of the description Barton shares rings true to citizen science—specifically, the idea that a scientist is one that 'enables a disempowered community.' In our case, citizen science, as it is experienced in the Methods course and more fully developed by the involvement of teachers, provides opportunities for individuals to learn in a responsibly embodied way, construct knowledge, and develop a set of skills that encourages learning from the "soils" or ground up, while sparking individuals to take action. Roth and Lee's (2004) description of embodied learning as "engagement in" rather than "preparation for" science is consistent with the way in which citizen science is conceptualized in this course. Morgan's belief that teachers should develop their philosophy of teaching in his class encourages ownership for meaning making through practice and opportunities to be involved in learning in an embodied way.

## **Preparing to Teach Science: Reflections from Rose and Paul**

Personal accounts of Rose and Paul are especially helpful in illuminating their philosophy of science education, and in turn their pedagogical understanding of citizen science. These accounts comprise the comments and observations over the semester, perspectives of the value placed in how and what they learn and acceptance for personal integration of a philosophy of education, which is inclusive of more than just societal expectations. As evidenced in earlier discussion, and further emphasized below, Paul and Rose share experiences because they are in the same class but express differing levels of appreciation for citizen science as a way of framing science instruction. The following reflections are based on documented comments by these individuals over the course of the semester.

### ***Rose***

Being outdoors was a good way to experience teaching. I understand why the chemistry and physics people in class had difficulties. To them it's just about getting dirty, but they could think of other things to use as examples for their teaching. It is important to get involved in the community, I want to do volunteer work and show the kids the whole citizen science thing so they have a choice to be outside rather than playing video games at home. Being an informal educator, I thought I had to change my teaching so that my class was more like how my

own experience looked. I didn't know I could be that way, because...follow the book, that is the way I was taught. I didn't know we could have a choice in that, and I was hoping that is what I could do – but I didn't know it was a possibility. So I am learning that it is a choice in the way you could be a very alternative teacher, as long as you are following the standards.

### ***Paul***

There is only so much time to cover the standards in my class, so spending time on citizen science ideas (being outside) can be a useless endeavor. I also have a, most likely thoroughly unrealistic, expectation that students are able to draw connections on their own between general principles and specific cases. That they are able to read a newspaper article on a water pollution case and understand the difference between parts per million and parts per billion and be able to identify the general classification of the chemicals involved (usually heavy metals or organics). In some contexts I don't think the effort required to stretch and pull environmental science in is really going to be worth it. Depending on what you are teaching, a lot of it doesn't fit very well.

In discussing the challenges in outdoor science education, Rose acknowledges her own struggle to work as an “informal” educator in a traditionally “formal” context. Over time, her perception of the differences between informal vis-à-vis formal education may be blurred by her practice of teaching science through an ecojustice philosophy. The evident value Rose places on social awareness (e.g., volunteerism) and protection of the environment may translate into a sincere citizen science pedagogy that will encourage an embodied responsibility within her students one day. On the other hand, Paul expresses the opinion that citizen science is something content specific and not relevant to all areas of science. The evident dichotomy of thoroughly immersing science education within the community (Rose) and the implication that students are required to find their own relevance (Paul) is but one differentiation between these beginning teachers that presents challenges for teacher preparation today. Are these beliefs based on individual experiences? If so, how does a teacher educator move towards preparation that encourages ownership of and appreciation for diverse approaches to teaching in science education? How do we nurture the development of teachers who are instrumental in protecting and preserving local communities?

## **The Challenges and Possibilities of Citizen Science**

Our study of citizen science as a framework for science teacher preparation provides insights for other educators into how courses can be modified to promote greater awareness for social and environmental justice issues. Using ecojustice philosophy

holistically, with citizen science methods (e.g., collecting data, designing protocol) as a central organizer for science teacher preparation courses, presents interesting challenges. In the context of this course, one of the greatest challenges is in positioning teaching as a process of preparing students for more than simple education—to help them think of education as a means of sincere preparation for future endeavors. Prospective teachers in this study are encouraged to view their experiences as ways of learning science, but also allowed to think of the larger purpose of why students are taught science (i.e., farming practices, local economy and environment). The prospective teachers are very aware of the foci on content area preparation nationally, initially feeling that their job is to help students meet the state and national standards for science, often at the risk of curtaining out relevant science within the local community. When the focus of the course appears to be on local issues rather than the state standards, many of the prospective teachers express frustration and worry that they are not being adequately prepared. In their minds, following a set of rules such as national standards means “good teaching,” and is often the only option they see as useful for their future as educators. Another challenge in this course is encouraging the future educators to consider the value of the outdoors as a learning environment (stepping outside of a normal classroom *per se*), and the significance of developing a sense of place in relation to the science learning of their future students. The outdoor learning environment includes rain, bugs, extreme heat and cold, and other uncomfortable issues that must be considered when learning to teach in such settings; these extremes prove especially difficult when prospective teachers are asked to contemplate using nature as a classroom. When Morgan and the other co-educators present alternatives to teachers’ images of what learning to teach science should be like, tensions emerge. While these tensions create an uncomfortable atmosphere for some, ultimately, as productive movements of change, they lead to dialogue and questions of what really needs to occur in science teacher preparation. Using citizen science as a framework for learning to teach is easily recognizable for many life science teachers, but the physical science teachers have more difficulty seeing how the relevance ties together with what they will be held accountable for in their core subject areas. We can appreciate this apprehension and as already mentioned, more time for reflection may have alleviated these pressures.

Despite the challenges, there are possibilities to consider. Beginning science teachers in this course express value for gaining exposure to ideas which do not seem to align with their previous instruction; they appreciate learning about different pedagogical approaches. Many indicate that the course experiences help them to develop a greater appreciation for culture and awareness for the diversity which will likely transition into their future classrooms and outdoor experiences. They describe a growing recognition of how citizen science can provide these connections needed to celebrate multiple forms of knowledge. While they express concern about the value that all science teachers might find with citizen science as pedagogy, the emphasis on a developing community helps many to seek ways of at least conceptualizing their educational philosophy. This conceptualization involves incorporating ecojustice philosophy within their existing belief structures, potentially blurring

the disciplinary lines. Consequently, citizen science is experienced as a pedagogy that has the potential, like other pedagogies, to blur the boundaries between and reduce the isolation inherent in teaching a single science subject. Moreover, the use of nature as a ‘teacher,’ presents these prospective teachers with opportunities to experience natural history, science, math, and language in interdisciplinary ways through authentic situations. The use of citizen science pedagogy as a framework for teaching involves an immediately accessible community (which takes time for the science teacher educator to develop—one huge drawback), but ideally with time, provides the prospective teachers with the kinds of tools they will need as they move to different geographic locations and seek to identify the resources their communities have to offer. This study highlights the possibilities of making ecojustice philosophy, embodied learning experiences, and we would add practitioner reflection central to the preparation of teachers who are equipped to meet the demands which tomorrow holds.

## Notes

1. All participants of this semester-long research study sign consent forms and are assigned a pseudonym. A table of participants is provided at the end of this chapter.
2. “Methods” is used throughout in reference to the course, which serves as the research setting, aptly entitled *Methods of Science Teaching*. It does not refer to a belief of what the class should be, nor what the professor intends. However, the title enhances the prospective teachers assumptions of what the course ‘should’ entail.
3. Ecojustice philosophy recognizes the interconnectedness of the living and nonliving, and encourages action, which emphasizes and celebrates this diversity by challenging currently held assumptions and allowing us to consider the alternatives to those beliefs.

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