Chapter 17
Democratic Participation with Scientists Through Socioscientific Inquiry

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Attempting to ground scientific knowledge in a relevant and meaningful context, the use of socioscientific issues (SSI) in the classroom seeks to encourage students to formulate a critical understanding of the interface between science, society and technology. While rhetoric on SSI in the science education community posits lofty goals such as citizenship education, enhancing students' connections to science, and empowering students for the betterment of society (Sadler et al. 2007), more research is now needed to investigate fully the potential of these targets. Most of the SSI research focuses heavily on the development of students' argumentation skills and consideration of multiple views in deliberation about controversial issues such as climate change and genetic engineering (Kolstø et al. 2006). While these are indeed valuable aims centered on important global issues, it is also imperative that SSI-focused education be situated in students' local communities, connected to their immediate interests, and tied to reflections upon their personal views and the critical dissection of multiple perspectives. Bolstering the SSI and local community connection provides opportunities for students to become active participants and contributors in their community (Hodson 2003).

Responding to calls for democratizing participation in science (Hodson 2003; Mueller et al. 2011) through the study of SSI, Claudia Melear (1999) argues that current preparation does not adequately enable preservice teachers (hereafter PSTs) to experience authentic inquiry participation in SSI and thus inhibits them from being able to provide these experiences for their future students. Consequently, we have seen in the research the multitude of reasons teachers reference as to why they do not feel comfortable teaching SSI in the science classroom (Hughes 2000).

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Melear recommends that training for PSTs should involve "hanging around with" scientists who have varying degrees of expertise, in order for them to be properly enculturated into the science they will be expected to teach. She argues that scientists have a unique role in the preparation of science teachers, and that pre-service teachers should be provided with research opportunities just as those opportunities are provided to students majoring in science. Her research suggests that science educators should work collaboratively and diligently with scientists to provide these kinds of opportunities for pre-service science teachers and moreover, they should be built into the teacher preparation curriculum. These aims were investigated in this study; thus, the question guiding this study is: *In what ways does incorporating a student-scientist collaboration into SSI-based instruction meet ideals of promoting democratic participation in science?*

Democratic Participation in Science

Frank Fischer (2000) provides a theoretical and pragmatic exploration of the relationship between citizens and experts, in questions of environmental management. Balancing expert perspectives with lay perspectives in policy discussions, which Fischer terms 'practical deliberation,' requires that lay-citizens be able to participate substantively in shaping discussions of local environmental concerns. Practical deliberation "seeks to bring a wider range of evidence and arguments to bear on the particular problem or position under investigation" (p. 78). According to this model, understandings of local environmental concerns can be normative and value-laden, but also incorporate knowledge funds ranging from direct observation of the effects of hazard exposure to interpretation of scientific claims in light of personal interaction with a contaminant. Studies theorizing *citizen science* characterize student participation in finding and implementing resolutions to environmental problems. These studies examine connections between (1) scientific uncertainty over environmental concerns, (2) the development of policies to regulate pollution and manage its effects, and (3) the contributions of lay publics to understanding and managing environmental risks. Irwin (1995) argued that local laypersons, or non-scientists, contribute unique and situated expertise and serve "not only in criticizing expert knowledge but also in *generating* forms of knowledge and understanding" (p. 112). It is here, within the exploration of SSI, that students can begin to understand as well as participate in scientific issues of personal relevance.

SSI's potential to increase students' democratic participation in science can be drawn from Chantal Pouliot's (2008) work with post-secondary students. She explains how students ascribed to a deficit model of citizen's knowledge and comprehension in public debates of SSI issues. She employs a framework that expands on the 1999 work of Michel Callon on the '*Deficit*,' '*Public Debate*,' and '*Co-production of Knowledge*' models of citizen participation in science. These models are differentiated in terms of the visions they provide of the legitimacy ascribed to the participation of citizens and scientists in debates, of the value and potential contributions of the knowledge held respectively by lay citizens and scientists, and of the roles of citizens in the production and dissemination of scientific knowledge. According to Callon (1999), the *deficit model*, as applied to citizen science, works from the premise that only scientists are able to grasp the full complexity of SSI. Under this model, exchange between scientists and citizens is predominantly unidirectional – namely, researchers inform a public that is considered to hold a deficit of the scientific knowledge needed to shed light on the issues being debated. The *public debate model* reconfigures the roles of scientists and citizens by encouraging interaction in spaces of public discussions. Citizens' knowledge, though different from that of scientists, is conceived of as enriching the problematization of SSI. The *co-production of knowledge model* is characterized by a redistribution of the roles of participation in the production of scientific knowledge that are integrated into the decision-making processes. Pouliot's (2008) case study of learners' perspectives within SSI illuminate that students ascribe to the deficit view of their role in science. She contends, along with many others (Roth and Désautels 2004) that SSI-based instruction ought to enable young people to position themselves as legitimate, competent partners in the SSI-related discussions with which their society must grapple.

A Class' Collaboration with Campus Scientists

A case study approach helped to define the boundaries of the unit of study (in this case, a class collaboration with campus scientists). Yin (2003, p. 13) asserts that a researcher chooses the case study design because he/she "deliberately wanted to uncover contextual conditions-believing that they might be highly pertinent to the phenomena of study." For this study, the phenomena of interest (PSTs' experience) and the context (a course which structured collaboration between PSTs and campus scientists) were intertwined in the case and a central part of the purpose of the research.

Twenty-four undergraduate PSTs enrolled (15 females, nine males; 2 African-American, 2 Hispanic or Latino, 20 White) in a Mid-western university class voluntarily participated in this semester-long study. The class, *Introduction to Scientific Inquiry,* was comprised of PSTs who expressed an interest in becoming elementary school teachers. PSTs were chosen for this study in response to literature asserting that science teachers often marginalize controversial issues in their classrooms and need opportunities to reflect on their deeper values and ideals with regard to teaching SSI (Reis and Galvao 2009). The overarching goal of the course was to engage students in authentic SSI-based inquiry. As such, activities throughout the semester centered on inquiry, the nature of science, data analysis and interpretation, and connecting learners with both the on-and off-campus scientific community with regard to local campus environmental science issues. The six participating scientists (three female, three male; ranging in age from 31 to 60 years) were selected because of their affiliation with the Office of Sustainability's project initiatives (i.e. transportation, water quality, energy usage, availability of healthy food options, greening computer usage, the adoption of e-books, campus community gardens…). The scientists agreed to attend one of the class sessions to brainstorm project ideas with the students and update on current happenings. They also agreed to communicate with them via meetings outside of class, phone, or email throughout the duration of the semester. Table 17.1 details the partnerships surrounding the SSI-based inquiry projects.

The data collection occurred during a semester-long period during the fall, 2010. Classes were held twice a week for 2 h each. Collaboration with the scientific community was held during class time. The author's reflective journal detailed field notes and ongoing commentary about student-scientist partnerships, which helped to aid in reflection on teaching and confronting assumptions about the collaboration between students and the scientific community. As well, PSTs maintained ongoing journals throughout the semester to reflect on their participation (see Appendix for specific journal prompts). The analytic process consisted of organizing the dialogical data (from field notes, interviews, and classroom observations) and identifying which data units were most likely to answer the research question (Carspecken 1996). Data were coded to classify the ideas and events that the participants referenced. Low-level codes were grouped together by constructing a hierarchy in which some codes subsumed others. This resulted in the formulation of a few large thematic categories that matched the analytic angles of the study- namely, agency, power, and empowerment.

PreService Teacher's Experience in Collaboration with Scientists

The findings stem from the construction and effects of a classroom experience that enabled an opportunity for democratic participation to occur with local scientists. In this study, "democratic participation" is investigated as a means to promote scientific literacy, i.e., employing scientific knowledge and skills to critically engage with contemporary issues and arguments (Levinson 2010). Furthermore, democratic participation here stands in contrast to research apprenticeships (Sadler 2010) or student-scientist partnerships whereby the student is meant to acquire the skill set of scientists and maintain an institutional hierarchy that largely neglects democratic participation. We see this in traditional citizen science programs as well- the essence of which has historically been for students to collect data that contributes to scientists' projects. As Angela Calabrese Barton noted, opportunities for democratic participation in these types of experiences are limited:

> Citizen science, as a tool, historically has not been about democratizing science-about offering multiple perspectives or transforming a knowledge base or a set of tools or resources- but rather has been about getting more work done (2012, p. 2).

Democratic participation by pre-service participants is thus aligned with Calabrese Barton's idea of *citizens' science* in which students employ deep and

Table 17.1 Description of SSI inquiry projects

Inquiry topic	Inquiry question	Project description	Science content embedded in project
Electronic waste	If provided with easy-to-access options for disposal, would students recycle their e-waste?	Group placed e-waste collection bins and educational flyers inside three residence halls to gauge amount of that could be recycled; conducted surveys to assess student awareness of and willingness to dispose of e-waste properly; their e-waste collection sites were adopted for use by the university	Environmental Science, waste effects
			Measuring, data collection, interpreting lab results
			Chemistry, elements, compounds
			Health, toxic hazards
Nutrition	Does nutrition awareness affect food choice among students?	Group conducted a pre and post analysis of 'healthy' vs. 'non-healthy' choices made by students after being made aware of nutritional facts; results helped develop a blog for motivating students to participate in a healthy eating campaign	Research-based guidelines for a nutritionally balanced diet
			Relationship between poor eating habits and chronic diseases
			Food processing effect on food quality, safety, nutrient content, and the environment
Energy	What motivates students and faculty to become more energy conscious and be actively involved in energy conservation?	Group surveyed students, professors, teachers assistants, and building managers from both the Chemistry building and a Dormitory in order to determine a plan of action for incentivizing energy conservation	Energy types, sources, conversions, and their relationship to heat and temperature
			Advantages and disadvantages to alternate forms of energy
			Inquiry process skills
Greening athletics	How much waste from our athletic dining halls could be diverted from the landfills?	Group conducted a waste audit at the athletic dining hall, sorting waste into Recyclable materials, Compostable materials, and trash to provide a percentage of waste that could be diverted from landfills	Advantages and disadvantages to alternate forms of energy
			Measuring, data collection, interpreting lab results
			Ecological degradation
			Advantages and disadvantages to alternate forms of energy
			Measuring, data collection, interpreting lab results
			Ecological degradation

critical analyses of their connections to community and their sense of place to leverage their contribution to conversations about science that directly or indirectly affects their lives. Here, democratic participation is assessed in the varied data sources through critiques of PST interactions with scientific community members and through an evaluation of all participants' analyses of the partnership.

PSTs Find Their Voices in SSI: "It Feels Like It Matters"

Opportunities to address problems of local concern allow PSTs to connect science in the community to their everyday lives. Basing their study of SSI in local issues is an essential part of curricular engagement as PSTs address problems of local importance and concern. In doing so, they are able to gather novel and important insights that give them an appreciation for the science in their lives and how it connects them to others:

> By working on inquiry projects on campus, I learned how science can directly affect our everyday lives. Between doing our hand-on experiments and researching online and in journals, I have come to see how one thing that seems small in science can have a big effect. This is the kind of thing where I find science most valuable; one scientific idea affects whole populations, including me (Amelia, Student Journal, 12.9.10)

The connecting of PSTs to environmental issues on campus immediately sets the tone of the classroom inquiry as one that focuses on the generation of solutions. PSTs naturally want to make their campus a better place and in desiring to do so they became easily involved in proposing solutions about what could be done to remedy a problem or create awareness about a campus environmental issue. In the poster below, developed by the group studying campus athletics for greener alternatives, PSTs propose the introduction of a composting alternative to waste management, based on their waste audit data of how much food is discarded at the stadium arena after football games. As one student in the group reflects (Fig. 17.1),

> I really liked how we engaged with interns on campus and have gotten a chance to explore real socio-cultural issues at our University. We acted like real scientists and stressed the importance of developing our own steps to fulfill this project's requirements, and got data we could work with to reach a conclusion (Brian, Student Journal 12.15.10)

Brian's fore-grounded claim that he 'acted like a real scientist' implies that he had to assume a role in which he could autonomously make decisions about what is important with regard to his chosen inquiry topic.

Jimmy echoed his sentiments about the authentic inquiry embedded in the projects due to their focus on local issues in which he felt he could take part:

> It felt like we did participate in the scientific community just based on the fact that we got permission to do a real project out and around the school. I have to say that it felt like it mattered as I compiled the data to come up with real interpretations. I think that is what I liked best about doing the project (Jimmy, Student Journal, 12.9.10)

The course curriculum fosters awareness of the science in students' daily lives, and also allows PSTs to experience authentic science within their place on the campus

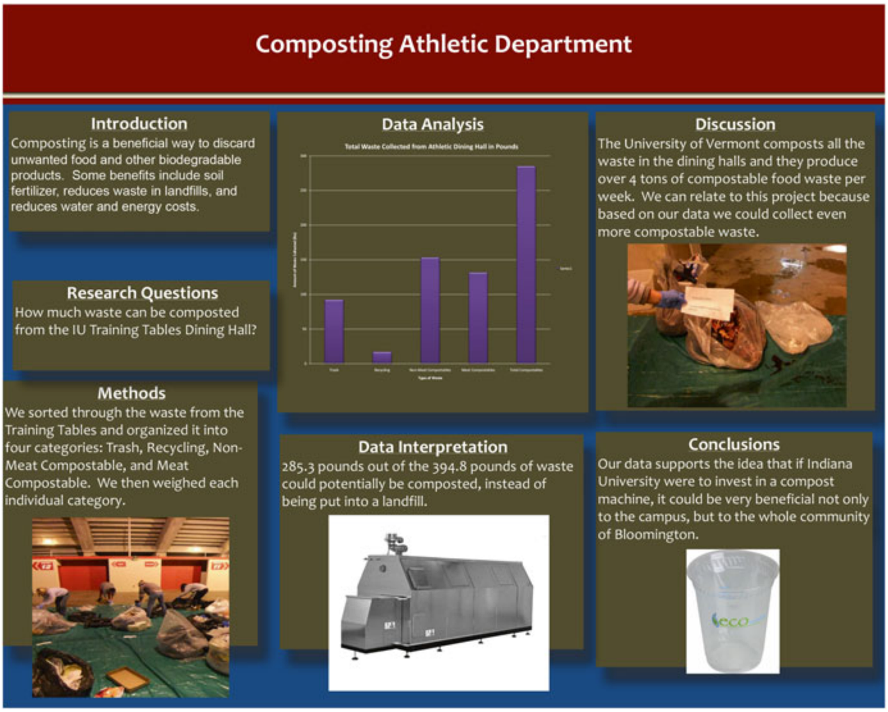

Fig. 17.1 Scientific inquiry project presentation developed by the greening athletics group (Classroom Artifact, 12.14.10)

environment, making science tangible and relevant. Moreover, locating the inquiry project in student's place also affords the opportunity for empowerment, as the information they uncover has the potential to be used by the campus community. The PSTs, through their inquiry experiences, come to view their role in science as important, often claiming they could affect the world through science:

> I did have some feelings about the environment and felt some remorse for what is going on in the world but there are something's that I felt were out of my hands. After taking this class I have realized that I have a lot more power then what I thought I did. (Richie, Student Journal, 12.9.10)

Richie's change in his role or identity with regard to science is an important part of the place-based inquiry that encourages him to engage in his project and get excited about his deepening understanding of science.

It is also important to note that the PSTs consistently reflect how, as future teachers, they will need to be able to draw out the experiences their students have with science in their daily lives: "*Students might not see an immediate connection, but it is a teacher's job to illuminate how science is involved with our daily lives*" (Student Journal, 9.1.10). As future teachers, several of the PSTs note this excitement when they think about their future profession:

> Ten years from now, as a teacher, I would like to be the one who does not decide to sit back, but help change the world instead of creating more harm while also encouraging my students to do the same (Addison, Student Journal, 12.9.10)

The PSTs, through their inquiry experiences, come to view their role in science as important. They immediately associate this new identity with their lives as future teachers. Even when unprompted, PSTs reference teaching SSI in the future, often claiming they could affect the world through science and hope to inspire their future students to do the same.

Challenging Assumptions About the Student-Scientist Collaboration: "I Worry That Students … May Come Off Sounding Naïve"

While planning this classroom experience for the PSTs, environmental issues are chosen to be the focus, as they allow for exploration of the science embedded in these topics and the societal implications inherent in them. A student notes in a reflection on his inquiry project, "*Environmental issues are part of pop culture, but also scientific and social*" (Charlie, Student Journal, 9.31.10). Along with my assumptions that everyone, even non-scientists, can offer something to conversations about the environment, I also assume that it is indeed possible for PSTs to enter into shared interests with practicing scientists where ideas are mutually valued. After all, none of the PSTs had worked alongside scientists in the past and their inexperience with this type of partnership led to concerns that they would not be adequately prepared to work with the scientists, to whom the work on campus environmental issues is their job. I worried that the PSTs involvement would be a possible hindrance to the scientists, and at best, irrelevant:

For his e-waste investigation, Tim Google mapped "electronic waste recycling" and did not get any hits for his Photovoice assignment. He concluded that there was no place in town to recycle unwanted electronic waste. Given the authors familiarity with this town and knowledge of a recycling center south of town that recycles batteries and computers, she advised Tim to dig deeper and research what the local recycling centers offer to take and became concerned about students' misrepresentation of data. "*Our Green Drinks presentation [with the campus scientists] is coming up next week and I worry that students may not be aware enough of the community/campus offerings and may come off sounding naïve*" (Researcher Journal, 10.13.10)

Because this experience is to be mutually beneficial to all, it is essential for the PSTs to be well-prepared, have the necessary understanding of terminology to talk with the scientists, and have unique knowledge to add to the discussions. In an effort to propose solutions to their chosen campus environmental issue, the students also realize they need to understand the background of their topic and what other universities or communities are doing. Also, because they know they will be collaborating with scientists on campus, they need to understand the science behind the topic rather than just the social implications of it. Their inquiry project (in which students investigate a testable question on their environmental topic by collecting data, analyzing the results, and proposing recommendations to scientists working on the issue) is based upon need-to-know information for their topic of interest:

> Prior to this class I knew the basic definitions that are involved with science, however after completing this particular course I now have a new understanding of the different vocabulary that is used. Rather than having little to no understanding as to why experiments are conducted and how different science approaches are useful, I better comprehend why different studies are performed and how scientists become so passionate about their topics of interest. My views on science have definitely broadened with the way this course is facilitated, based locally, and inclusive to the students (Keesha, Student Journal, 12.9.10)

The partnership, in essence, raises the ante of the learning as students are going to need to possess a deep understanding of the issues if they are to make valuable recommendations that will be well-received by the scientists.

Iteratively adjusting assumption about the PSTs' role in data generation became necessary. While I initially envisioned by the author that the PSTs would all conduct experimental investigations to contribute to the scientists' work, this, however, was not what the scientists wanted:

> I learned (in not so quickly of a time) that some of the Office of Sustainability's scientists want student perspective in the form of needs assessments. This makes sense because they want to have full control over implementation of their projects and full control over collaborations with necessary stakeholders. My students stepping in could confuse projects, roles, and perceptions. I have thus changed my initial requirement that students do experimental studies to allowing them to, when recommended, do descriptive studies. This qualitative data is no less scientific and is actually more useful for the campus scientists. As well, we have to wait for permissions for the experimental studies, which really slow our abilities to get started and progress (Researcher Journal, 11.8.10)

Instead of novel experimental designs, the scientists wanted to ascertain the students' perspectives and funds of knowledge on environmental issues on campus. Privileging experimental data collections as if that somehow made the students more helpful or legitimate as participants in the partnership did not meet with the expectations and desires of the scientists in this collaboration. The PSTs indeed are students and the scientists' interest in working with them is just that—to get the students' perspective. They want exploratory data showcasing public and student perceptions. My attempt to propel the students into being researchers were aimed at, in a sense, helping students become equals to the scientists rather than just allowing them to be students learning authentically and contributing to these issues.

Democratic Participation in SSI: "It Is of Vital Importance That We All Work Together"

The PSTs' involvement with the campus scientists is paramount in their feelings of inclusion in the scientific community. They frequently note that there is mutual benefit in their student-scientists partnership in terms of meeting their course goals as well as contributing data that would be useful to real scientists. In a class discussion about the tenets of the nature of science, Leona adds that her group's collaboration with all parties involved in the inquiry ought to be considered one of the essential tenets of conducting scientific inquiry:

> I feel that collaboration is such a big part of the success of science, and our group's success is no different. We have had to collaborate with the professor, the other people to implement our ideas on e-waste collection, the scientist who has been of the greatest help to us, and we have had to collaborate with the other e-waste group from the other class. All of these collaborations have been another key to the success of our project. There is no way only one of us could have done all of this research and planning. It was of vital importance that we all work together to come to an agreement and share our information and data on the project (Field Notes, 11.21.10)

Leona feels that the tenets of the nature of science need to include the 'collaborative nature of inquiry' as it is such an essential component of her ability to design and conduct her SSI-based research study. Thus, the experience of conducting their science learning outside of the classroom in an effort to impact and understand campus environmental issues necessitates a collaboration with those involved in environmental issues.

The PSTs also reflect on the importance of the scientists' involvement in terms of permitting them to conduct inquiries they feel are meaningful to the campus community. Hadley describes how her partnership with the campus food dietician is key to her group's ability to study and contribute knowledge to campus nutrition issues: *"She pulled a lot of strings for us so that we could collect data from a reputable chain restaurant. We couldn't have collected the data that we were able to, or even finish for that matter if it were not for the active participation that we received"* (Student Journal, 12.9.10). Hadley feels that the dietician is eager to help her group because she has an interest in their findings. Brian also works with the campus dietician and alludes to the important aspect of this collaboration in making his work on nutrition seem more like experiencing meaningful science learning. He says,

> I was doing many of the things that I thought scientists had to deal with such as setting up data collection and discussing with experts in the field. As for the data collection, it seemed very scientific. My group had to think through all of the possible ways to collect the data and decide which one would be most effective. As for meeting with professionals in the field, this was when I felt that the science was most legitimate. Raphael has studied nutrition for most of her life and collaborating with her on a project was really cool. She didn't control it though. We were still able to guide ourselves with her support. It worked really well and was enjoyable (Brian, Student Journal, 12.1.10)

Here, Brian illustrates that his experiences are 'legitimate' because they allow him to act like a real scientist, making decisions about how to collect and analyze data that a scientist would perceive as important and valuable. PSTs become more empowered to engage in science that affects their community as a result of working alongside scientists who consider their work meaningful.

Working with scientists on their inquiry projects allows PSTs to feel their impact on the scientific community is meaningful and valued, and that they are part of a team larger than just their class group. Having access to expert knowledge and obtaining permissions to conduct their various inquiries allows the PSTs to be in contact with the collaborating scientists throughout the semester. Therefore, the scientists are aware of the projects and make available opportunities to contribute meaningful data and recommendations that have the potential to be utilized by the scientists. For example, after conducting their food audits at the athletic dining halls, the PSTs are able to contribute the data they analyzed and make recommendations to the Office of Sustainability (which is closely working with the athletic departments to help facilitate more 'green' practices) that have an immediate impact on the campus. Based on their data, the PSTs recommend the use of a composting system and are able to inform others about the amount of food waste that would be re- directed into a potential alternative waste system. The PSTs' data is also used by scientists to advocate for funding for the composting system. Working closely throughout the project with their collaborating scientists, the PSTs discuss motivational issues to generate awareness among the athletes who frequent the dining halls about waste alternatives. The PSTs ask if they can create the design of a biodegradable napkin that can be placed at the dining halls for this purpose. It is unknown whether their design will be used in the dining hall, but the Office of Sustainability was provided with design and the permission to use it if they so wish.

This opportunity to generate knowledge that the scientists consider valuable and to create informational ideas to make other students on campus aware of the environmental issues they are investigating, helps PSTs feel that they are connected to the community through their engagement with science. Working with the scientists on their inquiry projects allows PSTs to feel that they can have an impact in the scientific community and that it is meaningful and valued. This close work alongside campus scientists throughout their conception, design, and implementation of scientific inquiry allows PSTs to be included in the scientific community whereby they have the potential of impacting real change on campus. Another contributing factor to the PSTs developing sense of empowerment through their inquiries is the fact that their research culminates in a final presentation at a symposium during finals week, whereby they have the opportunity to detail their experience and showcase the educational outreach component they develop as a result of this experience. Scientists and other students attend the symposium, and PSTs seem very eager to use their research to educate others about the prospect that their projects might make an actual difference on campus. Students are able to see the fruits of their labor culminate in a change on campus—namely, the opportunity made more readily available due to our focus on students' immediate community/place with which they have familiarity and ownership.

Science Education for Cultivating Activism

Many science educators support the idea that all students should have fair and equal opportunities to become scientifically literate through authentic, community-based science education (Roth and Lee 2004). However, this idea challenges teachers to find ways to help all students feel comfortable with and connected to science. This study provides insights into the ways in which a curriculum can be structured to meet the aforementioned goals. In effect, incorporating collaboration between students and scientists into the SSI instruction is essential to enhancing PSTs' connections to and feelings of inclusion in the scientific endeavor; however, it is paramount for opportunities for democratic participation to center on issues in and of student' communities and place.

Valuing Voice Through the Student-Scientist Collaboration

The structuring of this student-scientist experience closely aligns with citizen science (Cohn 2008) programs, though challenges the institutional hierarchy that historically has been associated with most citizen science programs (Calabrese Barton 2012). Attempting to account for the hierarchical approach to traditional citizen science programs, Wilderman et al. (2004) operationalize citizen science collaborations on a continuum of projects more directed by scientists (a "top-down" approach) to those more driven by learner interests and engagement (a "bottom-up" approach). Researchers have shown that bottom-up approaches to citizen science collaborations increase student (1) interest and engagement in the project, (2) ownership and understanding of the data, (3) building of community capacity, and (4) empowerment to act. Using Wilderman et al.'s guide to the categorization of citizen science, Table 17.2 shows the PSTs' collaboration with scientists to be characteristic of a bottom-up approach:

In this study, students identify the concerns and design their study, collect data, analyze and interpret the results. Finally, they turn their data into action. In this participatory process that centers in their own place on issues that have a direct or indirect affect in their lives, the PSTs' work alongside the scientists to seek solutions for campus environmental issues, allowing bonds of trust and mutual respect to develop. One aim of this project is to shift the power and locus of control for decision-making into the hands of learners and to build their confidence and capacity to gather and contribute knowledge for action in a participatory manner. Through this experience, the tight integration in the collaboration affords the PSTs to contribute meaningful data for the scientists, which is enabled through their developing research questions and data collection protocols created alongside the scientists. Having the scientists actually attend class early on in the semester is helpful in enhancing their burgeoning partnership. Through their discussions,

Table 17.2 Categorizing student-scientist collaboration using Wilderman et al.'s schema (2004)

Who defines the problem?	Who designs the study?	Who collects the samples?	Who analyzes the samples?	Who interprets the data?
Student	Student alongside scientists	Student	Student	Student

PSTs come to realize what information they need to understand to take part in community conversations about the environmental issues and increase their peers' awareness of these issues.

SSI to Promote Ideals of Democratic Participation in Science

Students may inadvertently possess a deficit model (Pouliot 2008) according to the manner whereby they conceive of themselves as legitimate participants in SSI. The deficit does not afford students opportunities to recognize the legitimacy of their unique lay knowledge, which stems from everyday experience, or the contribution of citizens to discuss science with scientists (Pouliot 2008). In this study, the curriculum empowers and encourages PSTs to develop a point of view concerning citizens' attitudes, interests and capacities that moves away from the deficit model toward a public debate model whereby they experience a two-way dialogic relationship with scientists. All of the PSTs experience a public debate model in their collaborative efforts with scientists. The materialization of their roles in the partnership depends on the structures of the student-scientists collaboration and the ways in which these malleable structures are flexed and negotiated.

Results from this study are consistent with research on apprenticeship programs whereby teachers work with scientists on their research. Sadler's (2010) review of research apprenticeships indicates that teachers feel more confident in their abilities to do science as well as teach science as a result of having experienced it firsthand through apprenticeship programs. Researchers have argued that increases in confidence levels result in a transfer of science research methods to classes where they teach or will teach in the future. It remains to be seen if the PSTs involved in this study will invoke community-based research alongside scientists in their future classrooms and moreover, if the structure of those partnerships will align with the goals for democratic participation.

With respect to SSI-based instruction, participation can be viewed through Callon's (1999) conceptual framework to further develop and enable learners to position themselves as legitimate, competent partners in the SSI-related discussions located centrally in their society. Participation in SSI-based environmental issues reflects a fundamentally different relationship between citizens and experts – one that requires the reciprocal sharing of power (Schusler and Krasny 2007). Regardless of whether or not their efforts are successful, engaging in collective action can enhance learners' understanding of social, economic, and political systems as they identify opportunities for and obstacles to realizing their vision. Ultimately, the privileging of student voice in the local community through student-scientist partnerships seems to be foundational for deepening the understanding and connection to science as a process. This underscores the authentic movement of PSTs into a fuller (and more empowered) expression of democratic participation in a scientific community shaped by inherent, yet malleable, boundaries. More importantly, the significance of this study lies in the extension of SSI curricula, which serves as a context for the empowerment and engagement of teachers.

Appendix: Journal Prompts for PSTs

1. Describe ways in which science is a part of your daily life.
2. Does the science you learn in school resonate with your own interests? In what ways?
3. Do you feel included in the process of science? How?
4. A section of the survey asked about your connections to environmental issues. What reactions did you have here?
5. How well have your science classes encouraged collaboration and cooperation between the students and the scientific community?
6. What kind of role do teachers play in the processes of science?
7. How would you describe the relationship you have with science?
8. Give an example of a time when you or other students had some input in the scientific community.
9. Do you think it's important for students to be engaged in the scientific community?
10. Imagine that the school made collaborating with scientists a requirement for all students. Would you agree or disagree with this decision?
11. Have you ever been involved with the scientific community? Why would this be a draw for students to join these communities?
12. What suggestions would you have for students collaborating with scientists?
13. Describe your experience at the community collaboration.
14. Tell me your understanding of the nature of science.
15. In what ways was the nature of science underscored in your collaboration with scientists? In what ways was it not?
16. Imagine an ideal experience of democratic participation in science. What does it look like?
19. Did you feel listened to by the scientific community? How important was your voice?

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