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Advancing Civic Science through University Students' Service-Learning with Youth

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Drawing upon Dewey's centering of science as a tool for democracy, the emerging field of civic science aims to strengthen the ties between science, citizenship, and democracy. In the study detailed in this article, the authors sought to understand whether and how university students who are aspiring scientists and science teachers develop civic-minded dispositions and competencies related to civic science. The study employed a qualitative research design that was exploratory yet conceptually rooted in civic development theory and emergent civic science approaches. Using prompted reflections focusing on the intersection of scientific and civic realms, this study explored the ways in which university students who participated in a two-semester service-learning course facilitating science outreach for youth made meaning of the connections between scientific and civic skills and dispositions, and how the service-learning experience influenced their civic identities. The study findings revealed varying levels of sophistication in students' understanding of the relationship between democracy and science; a spectrum of awareness about the ways inequity impacts younger students' relationship to science and about the implications for democracy and science; and important insights into the ways university students integrate their learning through applied science teaching into their personal civic identities. The article concludes with a discussion of the implications for well-designed service-learning opportunities in the sciences.

***Keywords*:** young adult civic development, service-learning, science outreach, civic science

Drawing upon Dewey's centering of science as a tool for democracy, the emerging field of civic science aims to strengthen the ties among science, citizenship, and democracy (Bäckstrand, 2003; Garlick & Levine, 2017; Spencer, 2015). In a recent article on civic science, Garlick and Levine (2017) called upon institutions of higher education to build the capacity of present and future scientists to act as civic partners and engage in public science. Toward this end, STEM disciplines, rooted in scientific habits of mind, may offer unique potential for university student civic development. Many pressing social and environmental issues require both scientific knowledge and citizen input. When science is conducted collaboratively, participants engage in deliberative processes that enhance skills for making democratic decisions together. In the study discussed in this article, we sought to understand whether and how university students who were aspiring scientists and science teachers-in-training developed civic-minded dispositions and competencies through facilitating science clubs for youth. Using prompted reflections centered on the intersection of scientific and civic realms, the study explored two research questions: (1) How do university students participating in a service-learning course over two semesters make meaning of the connections between scientific and civic skills and dispositions?; and (2) How does the service-learning experience influence civic identity formation in students? In this article, we first introduce the concept of civic science, placing it in conversation with the young adult civic development literature. We then describe the study project and share findings from the student reflections. We conclude with a consideration of the implications for well-designed service-learning opportunities in the sciences as they relate to the development of university students' civic identities and skills.

Literature Review: Civic Science and Civic Development

Civic Science

The emerging framework known as civic science elevates the role of the public in scientific endeavors and decision making, balancing citizen participation and traditional scientific expertise. In a foundational piece, Bäckstrand (2003) provided an overview of civic science, framing it as a contested term that serves as "an umbrella for various attempts to increase public participation in the production and use of scientific knowledge" (p. 24). According to Bäckstrand, civic science represents the shifting relationship among science, expert knowledge, and citizens within the science-politics interface and involves reframing scientific knowledge as a public good and citizens as both recipients of and actors in policy. Bäckstrand held up three ambitions for civic science: (1) increasing representation of marginalized people in science fields; (2) increasing citizen and civil society *participation* in the conduct of science; and (3) increasing the use of democratic principles in scientific inquiry and within the institutions of science, that is, shifting scientific norms and practices. Bäckstrand also maintained that civic science efforts have the potential to restore trust in scientific expertise, incorporate local knowledge in efforts to address complex and global environmental problems, and infuse the production of scientific knowledge with democratic principles.

Dillon, Stevenson, and Wals (2016) presented a similar heuristic of different conceptions of citizen-involved science that comprises a more transformative approach, which they referred to as *civic science*. They distinguished between science-driven citizen science, in which scientists lead projects that engage volunteers in the collection of predetermined data; policy-driven citizen science, in which government and science entities engage people in scientific inquiry addressing real-world issues, in hopes of creating support for particular policies; and, finally, a transition-driven civic science. In the less common civic science framework, the environmental problems that society faces require a different kind of relationship between science and society—a collaborative science steeped in identity and place in which inquiry, sensemaking, and action are co-created and scientists represent one group of stakeholders among many others that possess agency to address shared science-related issues.

Spencer (2015) emphasized the ways civic science can address “knowledge wars,” or the conflicting views on the overall value of science and expertise that obstruct public problem solving around science-related issues. Drawing on Bäckstrand's (2003) framing of civic science, Spencer (2015) argued that the democratic framing of civic science depends upon the recognition that science is political and requires civic agency. Spencer suggested that civic science is more than the application of scientific knowledge to public problems; it is a "key tool for human and community empowerment" (p. 214), the goal of which is for "scientists to act with citizens—as citizens—to change the world" (p. 214).

Likewise, Garlick and Levine (2017) prioritized the democratic purposes of civic science. Building on Boyte's (2011) definition, they described civic science as "a discipline that considers science practice and knowledge as resources for civic engagement, democratic action, and political change" (p. 692). They pointed to the erosion of public faith in science, increased polarization around public science issues (e.g., the Flint water crisis and stem-cell research), and, at the extreme, anti-science sentiments as grounds for shifting the practices, influences and culture of science through civic science. Similarly, Abbott and colleagues (2014) offered up civic science as a framework that encompasses a set of democratic and scientific practices that foster respect and facilitate public action toward positive public outcomes.

Civic science can bridge science and the civic capacities of communities and help redefine the roles of scientists, public citizens, and institutions of higher education in order to address today’s urgent public science challenges (Garlick & Levine, 2017). In a more civic science, scientists and policymakers are not the sole experts in decision-making processes related to public science issues; rather, scientists, policymakers, and public citizens are collaborators who engage in inclusive dialogue and deliberation for public aims and who centralize questions such as “What does it mean for a scientist to be an active citizen?” (p. 696). Garlick and Levine (2017) called for institutions of higher education to teach civic approaches to science that connect public science issues to students' core values, beliefs, and sense of moral and civic responsibility. Engaging in these approaches, especially through inclusive dialogue that creates space for

different viewpoints on potentially contentious science issues, will help instill and/or reinforce the idea that "science is as much about understanding scientific process and facts as it is about appreciating the humanizing principles that connect us" (p. 695).

Civic Development of Emerging Adults

There are echoes of Dewey in what Garlick and Levine (2017) and Spencer (2015) proposed. Dewey (1954) emphasized the strong connection between the scientific method and democracy: Making collective decisions in a democracy requires that people are versed in scientific habits of mind and that scientists can translate technical scientific knowledge into concepts accessible to the public. Dewey also argued that these capabilities should be developed in young people. Although Dewey referred mainly to younger students, colleges and universities can also foster civic development by offering opportunities for students to engage with others in public problem solving, dialogue, and service-learning (Flanagan & Levine, 2010). In fact, service-learning in science fields may have unique potential for university students' civic development due to the overlap of democratic practices and general scientific skills such as asking questions, exploring different ideas, weighing multiple possibilities, and experimenting with various models.

Science outreach through community engagement has the potential to impact university students' identities as aspiring scientists and developing citizens, and their future career trajectories (Laursen, Thiry, & Liston, 2012). Previous qualitative research has found that community-university science outreach partnerships influence professional socialization in three important ways, including enhancing scientific knowledge and skills, constructing personal meaning through direct involvement with science, and fostering a personal investment in the status and future of scientific fields (Laursen et al., 2012).

The professional socialization to which Laursen et al. (2012) referred comes at a key juncture in university students' development. In Erikson's (as cited in Cox & McAdams, 2012) eight-stage model of adolescent identity development, the "central crisis for adolescents is identity versus role confusion" (p. 2); however, Arnett (2007) argued that a new developmental period of "emerging adulthood" exists in industrialized societies, reflecting what Erikson described as "prolonged adolescence," spanning the period during which the greatest amount of identity exploration and development occurs (ages 18-25, approximately). Cox and McAdams (2012) identified a specific type of role confusion during this period of emerging adulthood, namely that of an individual's "relationship to his or her community and broader society, finding a way to be of service to one's community and wider world" (p. 3).

The Current Study

The current study used a qualitative research design that was exploratory yet rooted conceptually in civic development theory (Flanagan, 2013) and civic science approaches (Bäckstrand, 2003; Garlick & Levine, 2017). We explored how university students engaging in science outreach with youth in community settings made sense of science, the public, and their own civic and professional identities. The content and structure of the program offered a unique opportunity to ask university students about their perceptions of the intersection between scientists and citizens. During the service-learning project, the students—most of whom intend to pursue science-related careers—translate scientific principles into accessible forms for K-12 students (who come from a broad range of socioeconomic, racial, and ethnic backgrounds) and also facilitate group science projects that require them to attend to group dynamics and collective decision making. Over the course of one or two semesters, the university students engage weekly with the same community center or school. In addition to the outreach aspect of the course, the students also learn about youth development, science outreach, their community beyond the university, and society's structural inequities around access to science education. As late-adolescents/early adults, they are at developmental juncture where they are forming beliefs about their society and about their own roles and responsibilities as citizens and future science professionals. Their service-learning experiences represent fertile ground for beginning to understand the tensions and opportunities of a more civic science and for prompting reflection

on the relationship between science and democracy.

Course and Project Description

The ongoing science-outreach service-learning course has run for multiple years, and the program has long-standing relationships with local community organizations, science educators, and schools. Though elective, the course meets the requirements for a service-learning course. Specifically, the course introduces undergraduate and some graduate students to the process of teaching youth about science and offers them an opportunity to apply that knowledge in after-school science clubs at local schools and community centers. With the support of the centers' or schools' youth workers, the university students lead the science clubs, planning and facilitating hands-on activities and interacting directly with the youth. An individual student or a pair of students leads the science club at the same site throughout the semester. Selected community members and retired science teachers conduct observations of the science clubs and give the university students feedback, reinforcing the generative nature of science.

The course itself is designed as a two-semester sequence, with the majority of students participating in both the fall and spring semesters. The class meets weekly. The course and instructor provide foundational materials and guidance as the university students develop and implement meaningful hands-on science learning for youth. Students are also assigned to a smaller cohort for discussions and check-ins, and they complete weekly online reflections to which their cohort leader responds.

Method

The research team collected written reflections (part of assigned coursework) multiple times over two semesters from 29 university students participating in the science-outreach service-learning course. The team explained the study to the whole class, and students could consent to participate, which entailed allowing the team to access and analyze their reflections. The study was approved by the university's Institutional Review Board.

Sample

The sample consisted of 29 undergraduate and graduate students at a large public university in the Midwestern United States who enrolled in the elective science-outreach service-learning course, consented to participate in the study, and answered at least one of the study reflection prompts. Of those 29, five were graduate students, and 21 participated in two semesters of the course. Regarding known areas of academic focus, the largest groups of students were studying life sciences (14 students) and health sciences (6 students). One or two students from each of the following areas participated: physical sciences, social sciences, and education.

Reflection Prompts

Previous research has found that reflection activities are key components for the integration of service and learning outcomes and that more intensive reflection relates to better learning outcomes (Ash & Clayton, 2004; Eyler & Giles, 1999). Use of reflection questions can help to promote and transfer learning. In a meta-analysis of the effects of community service on adolescents, van Goethem and colleagues (2014) found that community service had positive developmental outcomes in multiple domains—academic, personal, social, and civic—when the service included reflection. Further, the content of reflection matters. Reflection focused specifically on civic attitudes, academic content/competence, and academic and career attitudes had significant positive effects for adolescent development (van Goethem et al., 2014). Reflection is a particularly strong moderator when the content of reflection matches the outcome domain; for example, reflection on academic and career attitudes stimulates positive outcomes in those areas, while reflection on civic attitudes yields positive civic outcomes. As van Goethem and colleagues (2014) suggested, academic-related reflection may promote understanding of both community and academic content as the theoretical and practical reinforce the impact of each.

Students in the current study responded to prompts at several points across the two-semester service-learning course as they worked in hands-on science projects with K-12 students. The reflection prompts were developed in collaboration with the main instructor and were informed by civic development theory, service-learning pedagogies, and civic science approaches (see Table 1). Students submitted their reflections to the online course page, and the mentor of their smaller cohort commented on each reflection.

Table 1. Select Reflection Prompts for University Students

Reflection Prompt	Timing	# of Responses
1. *Context*: What are you learning about the context (school, neighborhood, community, etc.) from your work with the science clubs?	Early 1st semester	21
2. *Teaching Young People Science*: Some of the young students you are working with will become scientists while others will not, but they will all be members of their communities, states, and nations. Why do you believe teaching young people about science—whether or not they become scientists—is important?	Early 1st semester	15
*3. *Future Generations:* As an aspiring scientist or teacher involved in science, describe how you view your role with and responsibility to future generations.	Early 2nd semester	19
4. *Scientists*: How might you be able to introduce or raise awareness with your children about scientists that look like them?	Early 2nd semester	23
*5. *Civic Engagement:* How do you see yourself engaging in civic or community issues in your career as a scientist or a teacher?	Early 2nd semester	19
*6. *Citizen Science:* Respondents were first given two different definitions for *citizen science* and asked to respond to the following prompt: Please use these as a starting point and write a paragraph (or two) giving your own interpretation of the phrase *citizen science* and how it relates to your own current or future work.	Early 2nd semester	19
7. *Addressing Racial Disparities:* Read the report on racial disparities in education in [the local city]. What role might you have in trying to address these issues?	Middle 2nd semester	21
8. *Roles:* After your experience in this course, how do you see the role of [the university] in the community, particularly in regards to sharing science? Secondly, how do you see your role as a student and a community member in [the local city]?	End of 2nd semester	21

Note. * Indicates questions were part of a separate online survey that were not considered course assignments.

The language and concept of *civic science* was not discussed explicitly in the course. Nonetheless, because of the content and context of the service-learning course (i.e., engaging in science outreach with

K-12 students), we expected that the university students would articulate the relationship between science and democracy and between scientists and citizens. We also expected that their reflections would resonate with theories of civic development and that reflections would reveal varying levels of sophistication and integration concerning elements related to civic science.

Analytic Approach

Written student reflections were transferred into qualitative data analysis software (NVivo, version 11) for systematic iterative coding and analysis (Coffey & Atkinson, 1996; Saldaña, 2016). For each student, responses to the series of prompts were read and analyzed together using both deductive and inductive approaches. We drew upon theories of civic development to code for expressions of civic identity development and civic skills but used more emergent coding for the relationships between science and the public. In the first round, three members of the research team coded the reflections using both inductive and deductive approaches. The team then reconvened to discuss emerging patterns and themes and to refine the coding scheme through consensus. Two members of the research team then independently coded another set of responses using the provisional coding scheme and then came back together to discuss and refine the scheme. This process was repeated for two additional rounds, when sufficient interrater reliability was achieved for the three main categories of the coding scheme (Cohen's Kappa = .841). All reflections were then re-coded. Our main themes emerged through analyses of the major categories of codes.

Results

From our analysis of student responses to all reflection prompts, three main themes emerged relevant to civic science and student development: (1) civic identity, (2) the relationship between democracy and science, and (3) science education and inequality. In the following sections, we first describe the variation among the three themes and share illustrative student reflections before discussing the implications of the results.

Civic Identities

Seider (2007) identified specific academic experiences among emerging adult university students as critical catalysts for solidifying students' identities as civic-minded individuals committed to public service. In the case of the university students who participated in this study, the semester- or year-long service-learning experience of community engagement through science outreach and mentorship created a unique opportunity for students to reflect upon their identities as civic scientists—that is, as both citizens and scientists—engaging in public life through their scientific expertise.

Relationship with Community

The ways in which the student participants discussed their civic and scientific identities, and the relationship between the two, reflected the developmental task of sifting through their personal beliefs about their relationships with community. These beliefs comprised a spectrum ranging from viewing oneself as a helper or savior in a community, to viewing oneself as a scientific role model for youth in a community, to viewing oneself as an integrated member of the community engaged in solving a complex social problem (Abbott et al., 2014). The responses also reflected differing understandings and beliefs about students' own civic agency, or power to act in concert with other citizens (Boyte, 2009).

> The following exemplifies the "helper" mentality expressed in some student reflections:
> The amount of volunteers from the [university] system is substantial and they truly better the community. I know without these people sacrificing their time for the good of the city, [this city] would be a much different place than it is. (Prompt 8)

Such perspectives reflected a unidirectional, rather than reciprocal, relationship with the community where the science-outreach projects took place. In some reflections, the helper framing of the work implied that the students' involvement in community had a positive impact that was not dependent upon collective

power and problem solving with others in the broader community.

Other students expressed their public identities primarily as those of role models. Students who identified with this stage of civic identity development reflected a commitment to community and to mentoring (as role models) the next generation of youth. At the same time, the students did not necessarily understand their role in facilitating civic development in this next generation.

> I think all [university] students should take on some role with children, especially since most kids see us as role models. We have the chance to get kids interested in science or other subjects; it is an opportunity for them to find their passions early on in life. (Prompt 8)

> I feel my role as a [university] student and a community member in [this city] is to just keep sharing my love for science and show people, especially kids, that science can be fun and interesting while still informational. (Prompt 8)

Some undergraduates described a sense of civic identity as scientists, viewing their roles as university science students as inextricably connected to the communities in which the outreach project took place:

> Before I had the opportunity to work at a local community center, I saw the [university] campus and the larger [city] area as very separate. It is easy to see myself within a more isolated community of college students; if I don't make the effort to cross the campus lines, I could easily ignore that there are families and children that live within my same community. After actively putting myself into that larger community, I think that it is [the university] student's responsibility to engage in the [local] community. As students attending a world class university, we should give back to the community that is fostering the campus. (Prompt 8)

> I am really grateful for the opportunity to volunteer at [the site] because I feel that it gave me a better insight to the [local] community, and really made me feel like I am a part of the community, and therefore have a responsibility to strengthen it. (Prompt 8)

Students who identified themselves as integrated members of the larger community articulated both a civic commitment to engage in and with community, as well as a sense of connectedness and oneness with the local community that exists beyond the bounds of the university. Unlike those students who reflected a "service" mentality, or those who saw themselves in a position of relative power as "expert" role models, these students identified as part of the communities in which they engaged. At the same time, they articulated a stronger connection between their civic identity in relationship to community and their professional aspirations as future scientists or educators.

Civic and Social Responsibility

Students' motivations for engaging in this science-outreach project differed, reflecting varying degrees of civic and social responsibility. A number of respondents expressed a sense of duty and social obligation in their reflections, with many students relating this sense of duty back to the notion of generativity, or a concern for guiding the next generation as members of society (Hastings, Griesen, Hoover, Creswell, & Dlugosh, 2015):

> We owe it to future generations to make science something accessible, so that students who do not go into scientific fields still feel a degree of comfort discussing these subjects. (Prompt 3)

> I believe [university] students have a duty to go into our community and work with young students. (Prompt 8)

> It is crucial for [the university] to help supplement underfunded areas of education and get kids

> excited about them. By getting these kids excited about science, there is a greater chance that maybe someday they will pursue a career in science and share their enthusiasm about science with the next generation of young scientists. (Prompt 8)

> The future generations are molded by the actions they witness performed by the older generations. My responsibility is to be involved and model positive actions so children can see these things as a reality. It is also my responsibility to get kids to believe in themselves. The future generation has a vast amount of potential, and it is up to me to get them to realize it. (Prompt 3)

A small number of students highlighted the salience of being part of a public institution (i.e., the university) and the resulting responsibility they felt to "give back" to the community that supports it:

> As a [university] student and community member, I have the opportunity to expand my knowledge by being a part in groundbreaking, government-funded research. Therefore, I also have the duty of giving back to the taxpayers by sharing not just research findings but the excitement of science in general with the public. (Prompt 8)

Importantly, some students articulated a relationship between social responsibility and personal benefits of community engagement:

> At the event tonight, one of my students was able to explain all of the experiments we had done. Her mom asked how elephant toothpaste worked, and she gave the completely correct explanation. I was almost brought to tears because I know I've made a difference in these kids' lives. I know I will always continue to be a supportive member of my community. (Prompt 8)

Taken as a whole, university students who were engaged in science outreach expressed civic identities rooted in the notion of generativity and framed within their self-perceptions as aspiring scientists.

It is important to note that, across respondents, university students were more likely to use generalities in describing the relationship between science and citizenship than they were to discuss their own personal identities as civic scientists. This somewhat impersonal analysis of the reflection prompts presents an as yet unfulfilled opportunity to motivate university students to think more deeply about their own civic and scientific identities.

Ultimately, this study yielded important insights into the ways university students integrated their learning through applied-science teaching and mentoring into their personal civic identities, as well as their motivations for doing so. Using science outreach with youth in community settings as a platform for developing civic competencies among the university students themselves, the students grappled with their own identities in relation to generativity and the development of future citizens and scientists among the youth involved. In some cases, it was evident that the students viewed themselves as having a role in facilitating the development of civic dispositions in younger students through their positionality as scientific role models and mentors.

Democracy and Science

Multiple reflection prompts throughout the service-learning experience provided students with an opportunity to articulate their perspectives on the relationship between democracy and science, and between citizens and scientists. Their reflections covered a wide range of associations but clustered around three main threads: (1) grappling with the roles of citizens and scientists in scientific pursuits; (2) noticing the transferable skills of science for more general community or democratic purposes (explicitly and implicitly); and (3) emphasizing the importance of science literacy of all citizens in order to address public, science-related issues.

Scientists and Citizens

Student responses revealed a range of views on the roles of scientists and nonscientists in scientific inquiry

and the outcomes of different approaches, including both prescribed and more collaborative approaches. Many students shared how they tried to emphasize to the K-12 students with whom they worked the idea that everyone is a scientist—that is, everyone can engage in scientific inquiry about the world around them. In the following excerpts, university students reflect on their efforts to work against the notion that only official, credentialed scientists engage in science or that "real science" is inaccessible to those who are not credentialed scientists:

> It is very important to explain to the kids that everyone can be a scientist. They need to understand that scientists are no longer only white haired men with glasses. They need to know that scientists come in every size, shape, gender and color. Since I started club last semester I have been trying to get it in the kids' heads that they themselves are scientists. That you do not need ten years of schooling and to be the smartest person on the planet in order to be a scientist. They did not agree with me at first but now are coming to the conclusion that they in fact are scientists. (Prompt 4)

> In my science club I had the students I work with define what a scientist does/is. Not one of them said something like "got a PhD," "works in a lab all the time" or "wears a lab coat." I got answers like "fixes things, explores, answer questions, uses evidence, listens, collaborates." This definition of scientist is not of a trained scientist specifically, but of anyone." (Prompt 6)

> In our modern world, it often seems like "qualified" scientists have this official responsibility of being the ones that should explore the non-human universe and bring that information to the human world. I think it is really important that people in general feel empowered to have their own relationships with all of the processes and cycles and mysteries that surround us. (Prompt 2)

Some students referenced the public distrust in science noted by Bäckstrand (2003) and Garlick and Levine (2017):

> Science in our country is at a strange place right now, where a lot of the general public doesn't trust science or have enough fundamental understanding to trust it. I feel my role is not only to conduct solid research but help in creating a wider understanding of the work scientists do, and that science is not some obscure thing locked up in a tower—anyone can understand and appreciate it. (Prompt 3)

Other students pointed to a more collaborative approach with scientists or institutions of science working with community members to address science-related issues:

> I think it's crucial for the [the university] to try to have a more meaningful role in the community. Sometimes I feel like the university can get very stuck in this academic world, analyzing everything from the outside without actually working directly with the community that it exists in. With that said, I also think it's important for the role of the [university] in the community to reflect what the community's needs are and what the desired level of involvement from the university is. (Prompt 8)

> Citizen science is not encouraged enough in our society. Our society is designed so everyone has their own place. People do not mix work with their home life because they want an escape from stress. If more people involved the community in science, people would have a greater appreciation for each other. It is crucial to combine the ideas of community members together to achieve a smoothly functioning society. (Prompt 6)

> The insights of kids and their guardians are just as valuable as anything I could "teach" them at the [site]… A sense of equality was/is vital. (Prompt 6)

Although less common, some students articulated a more limited scope of citizen involvement in science. One student expressed a deficit view of students' ability: "Many of the students who are not likely to become scientists don't have the natural mindset for science" (Prompt 2). Other students, as illustrated in the following reflection, viewed the role of citizens in science as being more in service to the scientists as opposed to collaborators:

> Engaging citizens in the scientific process can be extremely helpful to scientific projects. For example, a lot of ecological work is done around privately owned land. By letting locals take part in the data-collection, and allowing them to become involved in the story behind the research and why it is important, scientists gather community support for their work, and also access to land they wouldn't be able to study otherwise. (Prompt 6)

Transferable Skills

In their reflections, students mentioned many ways scientific skills and philosophies could be applied to all aspects of life. For this analysis, we focused on skills transferable to community or democratic processes. In many cases, students mentioned skills that are key components of democratic participation without explicitly linking those skills to democratic practice or civic life:

> The beauty of science is that it relies on many perspectives. Observations are the bread and butter of the scientific methodology, but one person's observations are not enough. (Prompt 2)

> In science club, they can work together as scientists by working through the scientific method. They can take each other's ideas and experiment by testing and retesting while working as a team. By doing this, they know that they are accomplishing great things together; it is not just individuals doing the work. (Prompt 4)

> One girl said it was hard when her group didn't use one of her ideas. I told the entire group that is one of the hardest things about science. There are many scientists in the world, and we all have to work together and share our ideas to make even better ideas. (Prompt 4)

In the previous reflections, students elevated perspective taking, attentiveness to bias, openness to multiple ideas, and the need for collective work—all key elements in participating in democratic spaces—without making a connection to community life. Other students made explicit connections between scientific skills and philosophies with participatory citizenship in democracy, indicating that the scientific skills of problem solving, working with others, asking critical questions, perseverance, finding and analyzing information, and experimenting are essential skills for participating in communities and addressing science-related issues. The following reflections demonstrate these more explicit connections:

> No society functions without community involvement. Children need to learn how to work with their neighbors, coworkers, bosses and other community members. When they learn how to communicate, they can become an important member of their community. They can make changes in their society when they have a mature voice. (Prompt 2)

> Because we have a democracy, it is important that the people are well-informed and able to think critically. (Prompt 2)

> During science activities, I try to mix up groups and give them all time to come up with their own ideas. After they begin working, I ask each group to share what they are doing. I believe sharing ideas and working together is an important step towards equality. I want all of the students in the class to know they are smart and have great ideas, whether they are black, white, female, male, or

> of any heritage. Working together at a young age and encouraging creativity and science will allow all students to feel equal and important. (Prompt 7)

Scientific Literacy

Emphasizing the importance of scientific literacy was a prevalent theme throughout the student reflections. Students mentioned how the general public's level of scientific literacy impacts everyone in areas such as voting on particular policies, energy consumption, interpretation of news, and openness to ideas:

> Our community needs to be scientifically literate because vanguard of change and advancement in society is directed by science. Citizens need to be able to understand not only where to get information and also how to process that information. Although it's not feasible for all citizens to get subscriptions to high-impact journals and get all of their information through that medium, they should still try to get information from purely scientific and unbiased sources. This way, they are aware of scientific evidence purported from various sources... However, not all members of society are scientifically literate, as a result, not only do they put their own children at risk, they put the rest of the community at risk. Obviously, scientific illiteracy can be a huge societal problem. (Prompt 2)

Many students also mentioned how the complexity and urgency of current science-related problems, such as climate change, necessitate both the scientific literacy and input of the public:

> Science illiteracy (and perhaps almost fear of science) is a pervasive problem in our country. It stunts conversation about how to move forward on ridiculously important issues we face globally (an obvious one being climate change). Increasing scientific understanding at a young age can only help with these issues. (Prompt 2)

> More importantly long-term, however, is the importance of understanding basic science concepts once these children become policy-makers, voters, parents, or teachers. The world is facing a number of difficult issues and crises that this generation of children will have to struggle with even more deeply than the current policy makers. (Prompt 2)

> We owe it to future generations to make science something accessible, so that students who do not go into scientific fields still feel a degree of comfort discussing these subjects. As issues such as climate change and what to teach in schools become increasingly political when they shouldn't be, a basic education in scientific knowledge and comfort in critical thinking is crucial. (Prompt 3)

Overall, university students held up the importance of scientific literacy for the general public, challenged ideas of who is qualified to engage in science, and identified scientific skills and philosophies that overlap with democratic life. Importantly, most of the responses reflected a youth development lens, that is, students were thinking about youth development as they considered the relationship between science and democracy.

Inequity and Science Education

Many of the science club sites were located in community centers or schools in under-resourced areas. As part of the university course, students read reports about racial disparities in education and listened to guest speakers who discussed the issue. The juxtaposition of the expressed importance of science literacy and collaborative scientific pursuits alongside a growing awareness of disparities in science education, access to scientific decision making, and representation in scientific endeavors prompted some students to begin

considering the relationship of science, democracy, and inequality, as well as their role in addressing it.

Many university students expressed surprise upon hearing from the K-12 students with whom they worked about how little time was spent on science in their schools and argued that the limited time (e.g., one hour per week) was insufficient for developing scientific understanding. Through the experience and conversations with the young students and with the youth workers at their community sites, some university students also began to understand how socioeconomic determinants could limit exposure to science learning at home as well, further exacerbating educational disparities. The following reflections illustrate this growing awareness among the students:

> Talking with some of the teachers in the school, I have found that they can never really assign homework because the parents just don't have the ability or literacy to help them with their homework. Almost no child will ever bring homework back. Additionally, suggestions to even just go out and observe the moon or clouds once home are largely ignored, as the parents are wary about letting the kids go outside, especially once it's dark out. (Prompt 1)

> Because science is taught in English in the bilingual classroom, I can imagine that this puts science in a uniquely difficult position, as the parents likely couldn't help with science homework or activities, even if they have the background science knowledge. (Prompt 1)

> These students have unequal opportunities as their more affluent peers. This causes a struggle because some of them do not have the same background experiences to help them understand some of the science concepts. (Prompt 7)

Students also pointed to the lack of representation of people of color and women in the sciences, and the importance of exposing young people to scientists who share aspects of their identities, as illustrated in the following reflection:

> Being aware of the fact that there are scientists out there who have a similar background and culture to themselves is important for young children who may have aspirations of becoming a scientist someday. Knowing that there are already people like them who have been successful helps them to believe that they too can be a great scientist if they work hard enough. (Prompt 4)

A few students expressed how, as students of color, they were proud to serve as role models for their science club youth and believed this expanded the youths' images of scientists. Many students also reflected on how science clubs that welcomed K-12 students into "doing science" could address the educational disparities about which they were learning. In the following response, the student explains how science clubs shift youths' perceptions of science:

> Especially, after reading the article about the disparity here in [our] county between disadvantaged children I know that science club is a step in the right direction to eliminate this disparity. Science club creates a sense of community for these children, who as the article states are geographically isolated most times. Additionally, science club is slowly starting to change the children's perception that they are not smart enough to do science or that they can never be scientists. (Prompt 8)

Overall, adding readings, inviting guest speakers, and responding to reflection questions focused on disparities in science education challenged students to think about and articulate their ideas on science and inequity. They also expressed a range of emotions regarding the issue, including surprise, concern, and anger.

Limitations

The study had certain limitations. First, although there was a high response rate within the class, not every person in the sample responded to every question. Furthermore, the results only represent the reflections of one group of students in one class; thus, the findings are not broadly generalizable. Future studies should

ask the same reflection questions of university students engaged in science-related community service or students engaged in science education courses without a service component to better understand the phenomenon of student outcomes at the intersections of science and democracy. Second, to a certain extent, social desirability might have factored into students' responses. While the online survey was anonymous, the requirements for the course included the reflection assignments, so students knew the instructor and their small-group mentor would read them. Finally, the students self-selected into this service-learning course that involved a high level of engagement with young people around science, so it is possible that these students differed in meaningful ways from other students in their prior experiences or their inclinations toward civic engagement or civic science.

Discussion

This study yields important insights into the ways in which university students integrate their learning through science-outreach service-learning projects into their civic and scientific identities. The students in this study reflected a strong commitment to advancing a more scientifically literate populace, yet there was variation in how students positioned themselves as part of the public with whom they engaged through this service-learning experience. They articulated the importance and transferability of science for democratic purposes to a greater extent than they expressed their development as civic scientists. Likewise, this group of students reflected a spectrum of awareness about the ways in which inequitable social or environmental factors impact younger students' relationship to science, as well as the implications of this reality for democracy and science. The structure of this service-learning course provided a space for university students to engage civically through science as adult mentors for K-12 students, while simultaneously creating opportunities for the youth to develop both civic and scientific dispositions. Though the reflection prompts created a pedagogical space for students to grapple with their civic identities as scientists, more explicit service-learning activities aimed at connecting scientific and civic identities would improve the training of scientists as science educators.

In analyzing the data, we discovered that university students articulated all three of Bäckstrand's (2003) key aims of civic science and also grappled with elements of Garlick and Levine's (2017) call to institutions of higher education. University students expressed the need to increase representation in the science field, increase citizen participation in science-related public issues, and, to a lesser extent, apply democratic principles in scientific inquiry and the university. By design, students reflected on the relationship among the public, science, and their own civic identities and responsibilities, which could serve as key components for teaching approaches to science that connect public science issues to students' core values and beliefs. By exposing future scientists to science in the public realm and engaging in reflection and discussions on the role of different stakeholders and on the notion of expertise, institutes of higher education can move to a more civic science as outlined by Bäckstrand and Garlick and Levin. In fact, many of the student participants saw themselves as having an active role in advancing the different aims of civic science.

In this course, university students did not work side-by-side with citizens to solve science-related public issues. However, by engaging youth in science activities, they had the opportunity to reflect on the nuanced relationship between science and democracy and the implications for their own role as future scientists. The outreach aspect of the course primed thoughts on civic identity and the public, but the university students may not have considered issues of civic science had they not been prompted. Posing civic-related questions to aspiring scientists within service-learning experiences fosters individual civic development and may potentially deepen the civic science conversation in scientific fields. Given that the students reflected different stages of civic identity development, this study's findings also point to the potential for scaffolding experiences to facilitate students' civic development in relation to civic science. For some students, more explicit conversations and reflection prompts about the relationship between being a scientist and being a citizen could be helpful. Through such processes, students might grapple with the question of who can weigh in on scientific issues, which serves as a precursor to the idea of public

deliberation on scientific problems. These building blocks for civic science could then serve as an ideological foundation for students to engage in collective community processes of public decision making around science-related problems. Finally, future studies should explore what preparation is needed for students from different scientific disciplines to engage in civic science service-learning or community processes. In STEM fields in particular, there are implications for how universities prepare faculty and staff to create the conditions that foster students' scientific and civic identity development.

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References

Abbott, S., Boyte, H., Jordan, N., Ottinger, G., Peters, S., & Spencer, J. P. (2014). *A call to action: Civic science and the grand challenges of the 21st century: A white paper for the Civic Science Workshop at the National Science Foundation*. Retrieved from https://ueaeprints.uea.ac.uk/id/eprint/55319

Arnett, J. J. (2007). Emerging adulthood: What is it, and what is it good for? *Child Development Perspectives*, *1*(2), 68-73.

Ash, S. L., & Clayton, P. H. (2004). The articulated learning: An approach to guided reflection and assessment. *Innovative Higher Education*, *29*(2), 137-154.

Bäckstrand, K. (2003). Civic Science for sustainability: Reframing the role of experts, policy-makers and citizens in environmental governance. *Global Environmental Politics*, *3*(4), 24-41. doi:10.1162/152638003322757916

Boyte, H. C. (2009). *Civic agency and the cult of the expert: A study for the Kettering Foundation*. Dayton, OH: Kettering Foundation.

Boyte, H. C. (2011). Constructive politics as public work: Organizing the literature. *Political Theory*, *39*(5), 630-660. doi:10.2307/23036076

Coffey, A., & Atkinson, P. (1996). *Making sense of qualitative data: Complementary research strategies*. Thousand Oaks, CA: Sage Publications.

Cox, K., & McAdams, D. P. (2012). The transforming self: Service narratives and identity change in emerging adulthood. *Journal of Adolescent Research*, *27*(1), 18-43.

Dewey, J. (1954). *The public and its problems*. Chicago: Swallow Press.

Dillon, J., Stevenson, R. B., & Wals, A. E. J. (2016). Introduction to the special section: Moving from citizen to civic science to address wicked conservation problems. *Conservation Biology*, *30*(3), 450-455. doi:10.1111/cobi.12689

Eyler, J., & Giles, D. E. (1999). *Where's the learning in service-learning?* San Francisco, CA: Jossey-Bass.

Flanagan, C. A. (2013). *Teenage citizens: The political theories of the young*. Cambridge, MA: Harvard University Press.

Flanagan, C., & Levine, P. (2010). Civic engagement and the transition to adulthood. *The Future of*

Children, *20*(1), 159-179. doi:10.2307/27795064

Garlick, J., & Levine, P. (2017). Where civics meets science: Building science for the public good through civic science. *Oral Diseases*, *23*(6), 692-696. doi:10.1111/odi.12534

Hastings, L. J., Griesen, J. V., Hoover, R. E., Creswell, J. W., & Dlugosh, L. L. (2015). Generativity in college students: Comparing and explaining the impact of mentoring. *Journal of College Student Development*, *56*(7), 651-669.

Laursen, S. L., Thiry, H., & Liston, C. S. (2012). The impact of a university-based school science outreach program on graduate student participants' career paths and professional socialization. *Journal of Higher Education Outreach and Engagement*, *16*(2), 47-78.

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Seider, S. (2007). Catalyzing a commitment to community service in emerging adults. *Journal of Adolescent Research*, *22*(6), 612-639.

Spencer J. P. (2015). Reflections of a civic scientist. In H. Boyte (Ed.), *Democracy's education: Citizenship, public work and the future of higher education*. Nashville, TN: Vanderbilt University Press.

van Goethem, A., van Hoof, A., Orobio de Castro, B., Van Aken, M., & Hart, D. (2014). The role of reflection in the effects of community service on adolescent development: A meta-analysis. *Child Development*, *85*(6), 2114-2130. doi:10.1111/cdev.12274