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How Physical Science Doctoral Students View and Value their Involvement in Educational Outreach in Graduate School

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Abstract

Educational outreach can benefit both the broader community and scientists themselves while fulfilling the service mission of many universities and funding programs. Involvement in educational outreach can benefit doctoral students, via improved teaching and classroom management skills, increased experimental design skills, strengthened sense of identity and belonging in science, and refined science communication skills. However, doctoral students are frequently encouraged to prioritize research over teaching or educational outreach. Understanding the complexities of their perceptions of educational outreach is important for supporting all doctoral students to receive the benefits of participating in this activity. In this study, we interviewed eight physical science doctoral students who participated in an educational outreach program at a medium-sized public research university. Cross-case analysis revealed that participants viewed both benefits and burdens to participating in educational outreach and reported feeling that outreach was less valued by their institution, their community, and, in turn, themselves.

Keywords: outreach, identity, higher education, doctoral education

Increasing and strengthening the communication of scientific research in accessible ways through educational outreach can benefit the broader community and scientists themselves (Brownell et al., 2013; Bubela et al., 2009; Komoroske et al., 2015) through increased science literacy and potential implications for public research funding (Clark et al., 2016). In this study, we operationalize educational outreach as an activity that provides a learning experience to a population that traditionally does not have access to that form of learning. National calls have been made to increase scientist participation in educational outreach and related professional development opportunities in science education and communication (American Association for the Advancement of Science, 2011; AAMC-HHMI, 2009; Anderson et al., 2011), as scientists must engage with their community in order to improve science literacy and the quality of science education (e.g., Alberts, 1991; Colwell & Kelly, 1999). Further, service, such as educational outreach, is central to the mission of many universities and funding agencies, such as the National Science Foundation, which values broader impacts (e.g., NSF, 2003; NASA, 2008). Despite calls for increased focus on educational outreach, efforts toward outreach and teaching are frequently devalued compared to research responsibilities in academia (Bartel et al., 2003; Moskal & Skokan, 2011), exemplified by the faculty reward structure that emphasizes research excellence (Laursen et al., 2012; O'Meara & Jaeger, 2006).

Doctoral students in particular need opportunities to develop science communication skills as well as scholarly interests aligned with issues in their communities or larger societal needs (e.g., Gaff et al., 2000; Walker, 2004; Weisbuch, 2004). Involvement in educational outreach helps doctoral students achieve these aims through promoting professional growth, application of knowledge, and connections with the community (O'Meara & Jaeger, 2006). Doctoral

students interested in pursuing careers in academia may need opportunities to engage in teaching and outreach in addition to the research work that is commonly emphasized (Laursen et al., 2012; O'Meara & Jaeger, 2006). However, academic structures that prioritize research send conflicting messages regarding the importance of service at the institution, and graduate students may feel that they too must devalue educational outreach in order to succeed in academia (Laursen et al., 2012).

In this study, we examined physical science doctoral students' perceptions of serving as educators as they volunteered in an educational outreach program called University Science Camp (USC; pseudonym). The graduate students volunteered time each week to design and facilitate fun and engaging hands-on science activities for traditionally underserved elementary students in their local community to increase engagement and interest in science. To inform understandings of doctoral students' valuation of educational outreach and identification with an educator role, we used a case study methodology in which we qualitatively analyzed semistructured interviews with the doctoral student participants in an effort to preserve the participants' voices and present thick descriptions.

Background

Graduate student participation in educational outreach has been examined previously (e.g., Clark et al., 2016; Houck et al., 2014; Laursen et al., 2012; Moskal & Skokan, 2011; deKoven & Trumbull, 2002; Wellnitz et al., 2002). Here we review the benefits and challenges revealed in these prior studies and the ways in which graduate students are shown to balance both when engaging in educational outreach.

Benefits to Graduate Students

Many studies have demonstrated how outreach programs led by university students can lead to improved attitudes toward science and increased interest for the K–12 students being served (e.g., Clark et al., 2016; Heinze et al., 1995; Houck et al., 2014; Koehler et al., 1999; Rao et al., 2007). Importantly, educational outreach programs can also benefit the graduate students who serve as educators through improved experimental design skills (Feldon et al., 2011), strengthened sense of identity and sense of belonging in their field of science (Rethman et al., 2020), and refined science communication skills (Clark et al., 2016; deKoven & Trumbull, 2002; Koehler et al., 1999; Rao et al., 2007). For example, Clark et al. investigated an outreach program in which doctoral students presented their research (in simplified form) to middle school students. Participation in the program improved the doctoral students' science communication skills and gave them new perspectives on their research.

Participation in educational outreach may improve graduate students' teaching and classroom management skills (Laursen et al. 2012). Specifically, prior teaching experiences and/or training, such as those gained through educational outreach, were shown to increase teacher self-efficacy and effective teaching practices of STEM graduate students (Boman, 2013; DeChenne, 2012; Fowler & Cherrstrom, 2017; Prieto & Altmaier, 1994). Competence of STEM graduate teaching assistants is similarly supported by their relationships with the students they teach, their relationships with their peers, and prior experiences and training that provide foundational pedagogical knowledge (Kajfez & Matusovich, 2017).

Challenges to Graduate Student Participation

The belief that a department most values research is common among academic scientists, including graduate students, postdoctoral fellows, and faculty members, which can be a barrier to participation in teaching and outreach (Ecklund et al., 2012). Systemic practices such as tenure review weigh research more heavily than outreach, teaching, or sharing knowledge outside rigorous academic journals. Additionally, STEM graduate students are frequently encouraged by their academic setting to prioritize research over teaching or outreach (Anderson et al., 2011; Bianchini et al., 2002; Feldon et al., 2011).

Graduate students may perceive negative responses from peers and faculty to their participation in outreach, along with messages that teaching is of a lower status than research (Laursen et al., 2012). Faculty may believe that efforts toward improving as a researcher will lead to improved teaching skills through an increased understanding of the subjects being taught; in contrast, faculty often do not hold the complementary belief—that efforts toward teaching will lead to improved research skills (Brawner et al.,

2002; Robertson & Bond, 2001). However, teaching experiences can lead to improvement on associated research skills and do add value to a graduate experience, even when research skills are thought of as the most important outcome (Bartel et al., 2003; Feldon et al., 2011; Moskal & Skokan, 2011).

Balancing Benefits and Burdens

Many graduate students who volunteer for educational outreach view their experiences positively, despite time constraints and departments' devaluing of such experiences (Andrews et al., 2005; deKoven & Trumbull, 2002). However, graduate students may believe that spending their time volunteering for educational outreach hinders them from obtaining highly regarded academic positions (Laursen et al., 2012). Institutions, communities, academia, and advisors must help graduate students to balance these mixed messages and see the benefits of participation, not only to the "image" of the university but also to the intellectual well-being of the graduate students themselves and the community they serve.

The limited prior research that has focused on challenges to graduate student participation in educational outreach largely examined perceptions of education in academia and institutional barriers to participation, rather than the challenges perceived by graduate students. In order to fill this gap, we investigated the burdens of educational outreach from the perspective of physical science doctoral student volunteers. Recognition of such burdens may have implications for ways to better support doctoral students to gain the benefits of participation in educational outreach and to fulfill the service mission of their institution. We theorize that the balance of these benefits and burdens in a doctoral student's experience might relate to their valuation of their educational outreach experiences and their identification with the role of an educator.

Identity Framework

Our examination of physical science graduate students' balance of benefits and burdens to educational outreach is informed by role identity theory (e.g., Stryker, 1980). A role is a position that one fills, such as a student, a scientist, or an instructor, whereas a role identity is how one relates to the characteristics of a role and the expectations of filling that role (Ashforth, 2001; Carter & Fuller, 2016; Stryker, 1980). In this study, we used this lens of role identity to explore doctoral students' perceptions of being an educator through participating in educational outreach. Specifically, through exploring perceptions of educational outreach, we gained insights into how physical science doctoral students view, value, and identify with the role of an educator, which they take on through their involvement in the educational outreach program.

Understanding the complexities of doctoral students' perceptions of participating in educational outreach is important for institutions to better support doctoral students as science communicators and researchers, preparing them to perform professional roles in academia and fulfill the service mission of universities. Additionally, deeper understanding of doctoral student perceptions of educational outreach may improve perceptions of outreach in academia and expand the population of doctoral students who benefit from participation in educational outreach. In this study, we used a case study methodology to address the research questions:

1. What benefits and burdens do physical science doctoral students associate with involvement in educational outreach?
2. How do physical science doctoral students value their involvement in educational outreach?

Methods

We chose to use a multiple case study methodology and inductive qualitative analysis methods in order to describe and learn from the experiences of individual graduate students in the bounded context of a particular educational outreach program (Miles et al., 2020; Yin, 2018). Each doctoral student participant is a case through which we examine the perceived benefits, burdens, and value of participation in an educational outreach program (Thomas, 2011). Thick description, often associated with case study (Yin, 2018), in combination with inductive analysis methods (Miles et al., 2020), allowed us to value and more accurately represent the voices of our doctoral student participants, which is essential to answering our research questions that concerned the perspectives of these students. We used cross-case analysis to reveal themes across participants related to each research question (Miles et al., 2020).

Context: Educational Outreach Program

Central to the university's mission statement is the tenet of disseminating knowledge and serving the state and the nation. The educational outreach program, University Science Camp (USC; pseudonym), fulfills the service mission of the university through its mission to foster science interest and curiosity through hands-on inquiry activities, particularly targeting racially minoritized and low-income elementary students for whom science outreach has been historically overlooked. USC has grown over its 10-year history; at the time of the study, each year doctoral students would run a weekly 2-hour after-school club for 9 weeks at two local elementary schools (one school each semester) and two week-long summer camps that campers attended for 6 hours each day. Camps and clubs consisted of a combination of content learning, science-themed outdoor games, and hands-on science inquiry activities. Additionally, doctoral student volunteers met weekly to plan for each day of club or camp, develop new content for the camps, coordinate access to schools, and facilitate these events. With support from the university to fund these endeavors, USC was fully and independently run by doctoral students.

Participants

Participants in this study included eight physical science doctoral students who volunteered for USC through their physical science department at a medium-sized mid-Atlantic public research university (Table 1). We chose to study doctoral students in this physical science department due to the large proportion of doctoral students in the department who were involved in educational outreach. More than 20% of the doctoral students in the department were included in this study, and a larger proportion participated in USC. It is a norm within the department for the doctoral students to participate in USC.

We acknowledge that our participants are not racially diverse, and we cannot capture the perspectives of racially minoritized doctoral students. Although this lack of racial diversity is reflective of the department from which participants were solicited, where more than half of the doctoral students are White and over 10% are Asian, it is a limitation to the findings of our study.

A multiple case study approach was used to compare the perspectives of the multiple doctoral students (Miles et al., 2020, p. 95). Each of the doctoral student participants gave informed consent to participate in this study, which was approved by the university's Institutional Review Board for human subjects research.

Data Collection

Participants were each interviewed one time for 1 hour. Each interview was audio recorded and then transcribed. The interview questions (Table 2) asked students to talk about their experiences in graduate school and USC specifically.

Note that Question 5 directly asks about educator role identity. We asked additional probing questions, such as "Can you tell me more about . . . ?", "How did that make you feel?", and "Why did you decide to . . . ?" based on participants' responses.

Analysis

First, we analyzed the data from each participant individually. For each participant, we started with carefully reading each interview transcript to get to know the participant as

Table 1. Self-Reported Individual Participant Summary

Pseudonym	Year in School	Gender	Race/Ethnicity
Alex	2	F	White, Asian
Austin	5	M	White
Avery	5	F	White
Blake	5	M	White
Charlie	2	M	White
James	2	M	White
Kelly	3	F	White
Quinn	3	M	White

an individual and to familiarize ourselves with the content of the interview. Next, we each read the interview again and individually created a list of main themes that the participant addressed in the interview, careful to note evidence for the presence of each theme. We then met to discuss and merge our individual analyses of the participant. Through our discussion, we created a final list of themes for the participant, based on evidence from our individual analyses and agreed upon through discussion. The first author then wrote a descriptive memo for the participant, which included a detailed summary of the ideas expressed by the participant in their interview and also helped to winnow the data (Creswell & Creswell, 2018). The second author reviewed each memo to make sure that it accurately reflected their understanding of the participant and to further strengthen the trustworthiness of the results. This entire process, repeated for each individual participant, is summarized in Figure 1.

Following the analysis of each individual participant, we engaged in cross-case analysis of the data to derive themes related to perceptions of educational outreach, perceived benefits and burdens to serving in educational outreach, and valuing of their role in outreach (Miles et al., 2020, p. 95). Together, through multiple discussions, we noted patterns across participant memos, grouped participants based on these patterns and other similarities in their themes, and contrasted and compared findings from each participant to generate meaning from the cross-case analysis (Miles et al., 2020). This analysis resulted in the findings presented in this article.

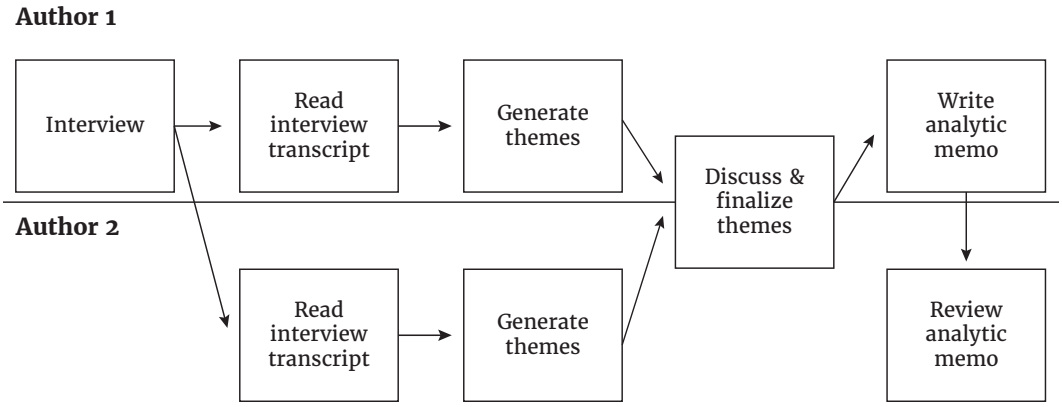
Researcher Positionality Statement

Because this study centers the voices and experiences of doctoral students, we feel that it is important to recognize that we, the authors, were doctoral students who studied STEM education at the time that data was collected and analyzed. As researchers studying education, we may be inclined to more highly value education experience and take a positive view of doctoral students serving in that role. In order to minimize our bias and center the perspectives of our participants, we were careful to listen to stu-

Table 2. Interview Questions

1. Can you please tell me the story of your experience in graduate school?
2. Why did you initially volunteer for USC?
3. Why do you continue to volunteer your time for USC?
4. What do you think you get out of volunteering for USC?
5. Do you feel like an educator in USC?
6. Do you value educational outreach for your future career?
7. Do you have any final comments about your involvement in USC?

Figure 1. The Flow of Inductive Analysis Used for Each Participant



dents' voices as they also discussed burdens to involvement in educational research. As doctoral students ourselves, we could relate to feeling both benefits and burdens in the same experience. Additionally, participants may have been more comfortable sharing both the benefits and the burdens with us in interviews due to our roles as doctoral student peers, which we hope provides a more full picture of doctoral student perspectives.

Findings

In this section, we present several themes in participants' understanding of educational outreach. First, participants identified as an educator in a variety of different ways, including taking on a titled, institutional role as an educator or through more casual experiences engaging in the practice of teaching. Participants reported feeling that an educator role and role identity was less valued by their institution, their community, and, in turn, themselves. Finally, they viewed both benefits and burdens to participating in educational outreach.

Perceptions of an Educator Identity: Engaging Formally Versus Informally

We explored participants' perceptions of the connections between the educator role and role identity in order to more fully understand the ways in which participants felt like educators in the context of participation in educational outreach. About half of our participants defined an educator identity through engaging in the educator role in a formal way. For example, James identified himself as an educator when he was in a formal educator role, standing in front of a classroom and lecturing, most likely in line with the way he was taught. Relatedly, he spoke about how he did not like to be in an educator role in this formal way because he did not like "educating the large groups of people who stare silently up at me." James expressed that he preferred discussion and working with a smaller group of students, "rather than me being like, 'Hello, class. I have prepared a lecture. Let me speak it to you.' I don't like that idea." Thus, although James identified as an educator only when he was in a formal educator role, he also expressed how he did not particularly like that definition.

In contrast, the other half of our participants discussed identifying as an educator when engaging in an educator role more informally. For example, Alex felt like an educator when she was effectively helping someone. Even when people, namely family or friends, asked about something not directly related to Alex's research, she would draw on her knowledge of the science from her classes and try to connect. She said, "They just want to talk about it. So then I'll say, 'Oh, yeah, I know about this. I learned about that in this one class.'"

These examples demonstrate the variety of ways that participants identified themselves as educators, varying from engaging in formal, institutionalized roles to informal conversations outside academic settings. These varied perceptions of what it means to be an educator are important to consider as we examine participants' views of being an educator through educational outreach. In the remainder of the findings, we highlight the ways that participants viewed and valued their experiences as educators in educational outreach.

Perceptions of the Value of Educational Outreach

All of the participants perceived educational outreach to be less valued than their other responsibilities as doctoral students, particularly their research responsibilities. This lesser valuing was demonstrated through discussion of the idea that by receiving certain funding, a doctoral student did not, as Austin said, "have to" teach, but if they did not have funding then they "had to" spend the summer teaching instead of "getting to" do research. We next discuss several examples of participants describing educational outreach, and by extension the educator role and role identity, being less valued by society and themselves.

Participants viewed serving in an educator role to be less prestigious, even when they found it fulfilling, due to the academic or societal attitudes around being an educator. For example, Blake said that he would like to work as an educator after graduating; however, he was conflicted because with all the work he had put toward his doctoral degree, he felt overqualified to be an educator.

> I'll have a PhD, and I have a lot of student loans. I want to make enough money for my worth. Unfortunately, a lot of the jobs where you'd be a camp counselor, things like that, you barely even need a bachelor's degree for some of them. And I think the time that

> I spent towards my education, I'm personally worth more than that. I wish and I think those educators are worth more than what they're getting paid, for sure.

Blake experienced tension between his beliefs about his personal worth of having a doctoral degree and his passion for outreach and elementary education, demonstrating his larger perception of being an educator as less prestigious.

Kelly's perception of her own future worth reflected similar ideas about the worth of educators in society:

> I worry about a lot of the types of jobs that I see myself leaving to do, like outreach sorts of things, aren't necessarily high paying sorts of things, which would be a little like "Oh I got a PhD and then went and continued making grad student money the rest of my life," which just seems like a shame. I'm not like trying to be rich but like, you know, I'd like to make more money than I'm making now.

Thus, although both Kelly and Blake reported that they might be happier leaning into their identities as educators, they felt that they would be less valued in society in that role than they would be if they leaned into their identities as researchers or scientists. Specifically, both participants saw the value of the educator and scientist role identities reflected in their associated earning potential.

The perceived devaluation of educational outreach experiences and associated identities is a potential burden that doctoral students must balance when considering participation in educational outreach. This finding reflects not only the participants' own perceptions of the value of educational outreach experiences and an educator identity, but also their perceptions of how others value educational outreach and educators. These societal perceptions then, in a cyclical feedback loop, impact the participants' values and, for Blake and Kelly, their career decisions.

Participation in Educational Outreach May Be a Burden

Most participants described how participation in outreach could, at times, become a burden as they tried to balance their role as an educator with their other roles and responsibilities as a doctoral student. For example, Alex perceived a conflict between USC and research that she felt made participating in USC more challenging.

> It does take away time from me researching and things but it's priceless when you interact with the kids and they get so excited about stuff that is so mundane to you. . . . And it gives me a renewed sense of why I'm doing this [doctoral program].

Alex was clear that she did value the benefits from participating in USC, despite the time conflicts. Unfortunately, many participants reported that they had to make involvement with USC a lower priority than research, despite the perceived benefits, due to time constraints.

In contrast, Blake felt that USC was the space where he was able to make an impact on other people, and so he chose to prioritize his role as an educator in USC over his other roles as a doctoral student. Blake stated that many of his peers felt "guilted" into volunteering, and he was frustrated that they were not making USC a priority. He said, "I just wish there were more people that didn't feel they were guilted into going to [USC], and more people that just wanted to." This parallels Austin's earlier statement about "having to teach" versus "getting to do research," and further illustrates the impact of the burden of "having to" rather than "getting to" teach.

Three participants described their perspective on feeling obligated to engage in educational outreach. For example, Quinn reflected about feeling obligated to engage in USC because it was aligned with his ideas of what it meant to identify as a graduate student at this university. However, he reported that he would not seek out this type of educational outreach if it was not readily available. He said:

> It's like "Oh, I'm a grad student. What should I do? What does a grad student do? Oh, outreach is one of the things grad students do here. As a grad student, outreach is one of the things I should do, we have this cool program. I should join it."

Charlie reported feeling pressured to participate in USC for the social connections

and did not especially enjoy working with the elementary students. He said:

> I felt unconfident in saying "no" to doing things with people. Sort of a fear of missing out. I didn't have a lot of friends in the department, and so I wanted to do this to spend more time with other people to become better friends with them. So I am not talking about how I love helping kids and things. I feel a little ashamed of that. But I think that's the truth.

Charlie felt that the benefits that he got from USC were related to his connections with the other doctoral student volunteers, instead of the elementary students. More specifically, he perceived the educator role to be defined by engaging in "kid wrangling and managing behavior," which he did not find fulfilling. Regarding participants' perceptions of managing behavior, Kelly discussed that the obligation to engage in classroom management aspects of educational outreach did not make her identify with either the educator or scientist roles. For example, she said:

> We've had a few instances with really bad behavior. And so I feel like a decent chunk of [Outreach] is yelling at kids, trying to get them to do what you want. And it's hard to really feel like I'm a scientist yelling at these children to just stop throwing rocks at each other. . . . Which, I don't mind, but definitely not like "Oh I feel like a scientist today."

Kelly's quote, in particular, demonstrates that even when doctoral students do not view engaging in educational outreach overall as an obligation, certain requirements of such participation can feel like a burden.

Finally, Blake, Kelly, and Austin, who were formal leaders of USC, perceived that the department occasionally took advantage of doctoral student labor via the time they volunteered for USC, which was an additional burden to the doctoral students. Blake praised the program, saying, "I think everyone around the community thinks of us as this awesome group without realizing that we're just like 15 grad students doing stuff. Which is awesome." However, Blake also acknowledged the nature of volunteering his time. "I wouldn't be surprised if some of the people that I've interacted with think that it's my job to do outreach, and don't realize that it's just volunteers. And so I think the community's really appreciative of it." The doctoral students were not being compensated, financially or through progress toward their degree, for the significant amount of time they spent toward USC, despite the large impact it was having and the way it strengthened the relationship between the university and the surrounding community.

These quotes demonstrate that participants had to balance the benefits against certain burdens when deciding to participate in USC. Specifically, they experienced time constraints and occasionally felt pressured into volunteering when they did not want to. In the next section, we explore the perceived benefits.

Perceived Benefits to Participation in Educational Outreach

All of the participants described some amount of benefit to participation in USC, including relief from other pressures of graduate school, increased social or "soft" skills, professional benefits, and connections to their community. We discuss each in more detail.

Personal Benefits

Participants described the ways in which they benefited personally from their involvement in USC. For example, Austin said that involvement in USC was a "release from doing research-y things and classes," and he chose to make time for outreach despite the other pressures of graduate school. He said:

> I felt that it was even more important to do that [USC] then so that I would have a break from doing other things. . . . So instead of just sitting at my desk, trying to type out words and think really hard, just go do something tactile which doesn't require that much brainpower. So it's a nice sort of relaxer in a weird way.

About half of the participants also discussed USC as a break from their other responsibilities.

Additionally, most participants valued the soft skills that they gained. For example, Austin described gaining management and event planning skills, specifically "being a

good team player, working with the team, managing time, managing people, trying to see the bigger picture of what we're doing, try to connect with people, connect with, well, in this case, the kids." Kelly said that she gained similar soft skills from volunteering for USC, such as "public speaking, and confidence, organization." Kelly was a formal leader in USC, and perceived that she developed "really useful skill" from that leadership experience, specifically. She said,

> I think that taking ideas from a range of people and responding openly to them is something that I need to work on, because sometimes I get caught up in my own ideas and my own plans, and so having to lead this group of people with different ideas and different plans has kind of been an important exercise for me.

The soft skills gained through educational outreach were perceived to have benefits in participants' future STEM careers, in other educational outreach settings, and also in the many other roles they may take on in the future.

Together, these quotes demonstrate that relief from other pressures of graduate school and increased soft skills were both personally beneficial to participants in the moment as they participated in USC and could also benefit participants in the future.

Professional Benefits

Involvement in educational outreach inspired Kelly and Blake to want to take on educator roles in the future through shaping their educator identities. Kelly reflected that volunteering for USC caused her to more highly value interacting with and educating people in her future career, a change from her initial goal of pursuing a research career. This change was strongly related to the "personal enjoyment" she felt from participating in USC. She said that it made her "feel good to work with kids." Blake, too, described how his career goals were changed through USC, saying, "I effectively want to just be a science communicator in the future. It is what I think I'm good at. And I enjoy doing it." These quotes demonstrate how participation in educational outreach can help refine doctoral students' goals.

The professional benefits many former doctoral students received through USC inspired some participants to get involved in USC or to continue to volunteer their time. For example, Kelly explained:

> I know for a fact that it has significantly impacted several people's careers, helped them get jobs to be able to say they have this outreach experience, they have this outreach connection. Even from people staying in [science], there's several grants that want to see that you're doing this sort of outreach and to say that you're so involved in such an intensive, impactful sort of program where you even have statistics to prove how impactful you've been.

Participants discussed two different benefits. First, the evidence that involvement in USC had been useful to former doctoral students in getting a job was beneficial to the current doctoral students in the department, as it helped them feel that their volunteer work for USC would be recognized as valuable. Then also, doctoral students who volunteer their time for USC may benefit in their job search.

Overall, participation in educational outreach could benefit participants through refinement of their career goals, as they gain the knowledge that they either do or do not want to be in educator roles in their future. It also can make doctoral students competitive for the careers they might pursue.

Community Benefits

Participants also reflected on the benefits received by the local community from USC. Specifically, Kelly discussed educational outreach as a "great tool for bringing science to the public in a palatable, exciting way" and benefiting her community. She said:

> People want to hear more about it. And I think that's a great way of also teaching them why you should trust all science and a way of making people have a sense of the robustness of science and what it means to be a scientist, and that sort of thing.

Similarly, Blake and Alex felt that educational outreach was a way to connect with other people through an interest in science. Blake said, "It's probably my favorite part about [science] is how much people want to listen to people talk about [science]." Alex

said about talking to community members about her research,

> Seeing them excited, it gets me excited too. It's a wonderful thing to tell something to someone that they've never heard before. And talk to them about it. And that reinforces the fact that I'm in this program, and I am learning, and I know what I'm talking about. And I can communicate it.

Together, these quotes demonstrate both the benefits to the community and the ways that doctoral students are fulfilled by connecting with the community. Further, the personal and professional benefits of communicating about science topics and identifying as a scientist are deeply tied to the connections participants are making with their community.

These examples of personal, professional, and community benefits summatively demonstrate participants' positive perceptions of participation in educational outreach and their understanding of the benefits that they felt they gained through volunteering. Notably, participants predicted that the benefits would last beyond their graduate school experience and into their future.

Discussion and Implications

The participants in this study recognized many of the same benefits to being in an educator role through educational outreach that have been identified in prior studies, such as improved teaching and classroom management skills (Laursen et al. 2012) and refined science communication skills (Clark et al., 2016; deKoven & Trumbull, 2002; Koehler et al., 1999; Rao et al., 2007). By examining doctoral student participation in educational outreach through a role identity framework, we expand on prior literature to demonstrate additional benefits to participating in educational outreach perceived by doctoral students. These benefits include increased confidence and social skills, relief from other pressures of graduate school, and educational outreach as a tool for promoting science literacy and benefiting the local community, in line with the service mission of many universities and funding agencies. Connections to people in the local community through science educational outreach strengthens science literacy in the community and demonstrates for doctoral students their potential to use science to make changes in people's lives.

Although doctoral students in this study reported benefits to participation in educational outreach, they felt they were not receiving support or compensation for the important work they were doing, fulfilling a part of the university mission and representing the university to the community. The lack of perceived support and compensation reflects an issue with the way that educator professions are valued in society and financially compensated more broadly. For example, our society pays STEM professionals more than teachers, directly representing prestige that makes it a difficult decision for STEM students to choose to educate others. This devaluing of the role of educators was further perpetuated by the doctoral students, as demonstrated by participants' perceptions that they were overqualified to pursue careers in outreach and would not be satisfactorily compensated, despite their reported passions for and fulfillment from participation in educational outreach. Doctoral students who may identify as educators and who feel they can have a large impact on their community via working as an educator may perceive that their work will be less valued and, as an extension, that they will be less respected in their community if they choose to focus on education. By understanding the significant influence that institutional values, demonstrated through support for and prioritization of educational outreach, may have on doctoral students' perceptions of their identity and potential careers, institutions of higher education might be able to counter the systemic devaluing of educators through increased support and compensation for doctoral students' engaging in educational outreach efforts.

Our results demonstrate ways in which an institution can shape perceptions of the value of educational outreach and, in turn, the value of an educator identity by recognizing and supporting, or not recognizing and supporting, time spent in that role. For example, participants in this study reflected that their institution did not financially compensate them for the time they spent promoting the university through USC and that their time spent toward science education and outreach was not recognized in considering their progress toward their degree. Thus, the university directly shaped the ways that the participants viewed and

valued educational outreach and the educator identity. Institutions might demonstrate that they value the educator role by rewarding and promoting participation in educational outreach through financial compensation, credit hours or other forms of recognition toward a student's record of progress or a professor's tenure and promotion, professional development opportunities to support individuals to become better educators, highlighting opportunities for doctoral students to make their participation in educational outreach part of their research work, and changing and clarifying expectations regarding the allocation of time so that individuals are able to spend time in educational outreach. Overall, institutions might recognize educational outreach as a form of academic service that is as valuable to the scholarly community as reviewing journal articles or serving on committees.

Although participation in USC was voluntary, results suggest that some participants felt fulfilled by participating, and others felt that their participation was a burden. This dichotomy reflects Gee's (2000) concept of an institutional identity, which is a role identity that is recognized by an institutional authority and can be either a "calling or an imposition" (p. 103). This study adds to the body of literature around educational outreach by highlighting the voices of those participants who may view educational outreach as a burden but still recognize its benefits; although some participants expressed that their participation at times felt like a burden rather than a calling, all participants perceived some amount of benefit from participating in outreach. To increase the number of doctoral students who are able to receive the benefits of participation in educational outreach, advisors of doctoral students might promote the benefits and work to reduce the burdens. For example, advisors can engage in outreach and teaching to model for doctoral students how to balance their time between research and outreach or teaching.

Limitations and Future Research

All study participants were solicited from participants in a single educational outreach program. Drawing from this population allowed us to examine their particular context in greater detail, but may limit the transferability of these findings. Future research might examine doctoral students' perspectives on educational outreach across multiple contexts, such as research universities, teaching universities, and different sized institutions.

Some students choose to study at this particular institution due to the opportunity to serve with USC. Such widespread participation in educational outreach in a physical science department is not common and may have influenced the perceptions of educational outreach of participants included in this study. Future studies might compare the perspectives of doctoral students who participate in departmentally sponsored educational outreach to the perspective of doctoral students who seek out their own opportunities to participate in educational outreach.

Finally, the lack of racial diversity is a limitation to this study, as we could not capture the perspectives of students from racially minoritized backgrounds in STEM. Lack of racial diversity is also a limitation to the educational outreach program itself, as the demographics of the doctoral student volunteers may not reflect the populations that they aim to serve and may leave an impression of science as White. Future research might further explore the benefits of science educational outreach on the identities of doctoral student participants from historically minoritized backgrounds in STEM, as research suggests that social outcomes may be more important to the career goals of these students (Garibay, 2015). Future research might also investigate how the K–12 students being served might be impacted by the racial identities of the doctoral student educators.

Conclusions

This study focused on participation in educational outreach from the perspective of doctoral student volunteers in order to provide insights into the burdens and benefits. Participants in this study did perceive many benefits to participating in educational outreach; however, they also discussed burdens, including the feeling that outreach was less valued by their institution, their community, and, in turn, themselves. Identifying perceived burdens may help faculty and institutions work to reduce those burdens and better support doctoral students to gain the benefits of participation in educational outreach and fulfill the service mission of their institution.

This study highlights how doctoral stu-

dents must be supported to participate in educational outreach and how educational outreach experiences must be valued in academia. Although an institution's mission statement may nominally value education and outreach, students at the institution may be receiving a contrasting message of outreach that is not supported or is at odds with other institutionalized goals (i.e., research). Thus, institutions might better support students and their service mission through endorsing opportunities for students to work as educators and valuing these experiences in hiring and tenure decisions.

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References

Alberts, B. M. (1991). Elementary science education in the United States: How scientists can help. *Current Biology, 1*(6), 339–341. https://doi.org/10.1016/0960-9822(91)90185-y

American Association for the Advancement of Science. (2011). *Vision and change in undergraduate biology education: A call to action*. https://www.aaas.org/sites/default/files/content_files/VC_report.pdf

Anderson, W. A., Banerjee, U., Drennan, C. L., Elgin, S. C. R., Epstein, I. R., Handelsman, J., Hatfull, G. F., Losick, R., O'Dowd, D. K., Olivera, B. M., Strobel, S. A., Walker, G. C., & Warner, I. M. (2011). Changing the culture of science education at research universities. *Science, 331*(6014), 152–153. https://doi.org/10.1126/science.1198280

Andrews, E., Weaver, A., Hanley, D., Shamatha, J., & Melton, G. (2005). Scientists and public outreach: Participation, motivations, and impediments. *Journal of Geoscience Education, 53*(3), 281–293. https://doi.org/10.5408/1089-9995-53.3.281

Ashforth, B. E. (2001). Role identities. In *Role transitions in organizational life: An identity-based perspective* (pp. 23–51). Lawrence Erlbaum Associates, Inc., Publishers.

Association of American Medical Colleges and Howard Hughes Medical Institute [AAMC-HHMI]. (2009). *Scientific foundations for future physicians*. https://store.aamc.org/downloadable/download/sample/sample_id/207/

Bartel, A. S., Krasny, M., & Harrison, E. Z. (2003). Beyond the binary: Approaches to integrating university outreach with research and teaching. *Journal of Higher Education Outreach and Engagement, 8*(2), 89–104. https://openjournals.libs.uga.edu/jheoe/article/view/619

Bianchini, J. A., Whitney, D. J., Breton, T. D., & Hilton-Brown, B. A. (2002). Toward inclusive science education: University scientists' views of students, instructional practices, and the nature of science. *Science Education, 86*(1), 42–78. https://doi.org/10.1002/sce.1043

Boman, J. S. (2013). Graduate student teaching development: Evaluating the effectiveness of training in relation to graduate student characteristics. *Canadian Journal of Higher Education, 43*(1), 100–114. https://doi.org/10.47678/cjhe.v43i1.2072

Brawner, C. E., Felder, R. M., Allen, R. H., & Brent, R. (2001). *Faculty Survey of Teaching Practices and Perceptions of Institutional Attitudes toward Teaching, 1999-2000*. Southeastern University and College Coalition for Engineering Education. https://files.eric.ed.gov/fulltext/ED461510.pdf

Brownell, S. E., Price, J. V., & Steinman, L. (2013). Science communication to the general public: Why we need to teach undergraduate and graduate students this skill as part of their formal scientific training. *Journal of Undergraduate Neuroscience Education, 12*, E6–E10. https://pubmed.ncbi.nlm.nih.gov/24319399/

Bubela, T., Nisbet, M. C., Borchelt, R., Brunger, F., Critchley, C., Einsiedel, E., Geller, G., Gupta, A., Hampel, J., Hyde-Lay, R., Jandciu, E. W., Ashley Jones, S., Kolopack, P., Lane, S., Lougheed, T., Nerlich, B., Ogbogu, U., O'Riordan, K., Ouellette, C., . . . Caulfield, T. (2009). Science communication reconsidered. *Nature Biotechnology, 27*(6), 514–518. https://doi.org/10.1038/nbt0609-514

Carter, M. J., & Fuller, C. (2016). Symbols, meaning, and action: The past, present, and future of symbolic interactionism. *Current Sociology, 64*(6), 931–961. https://doi.org/10.1177/0011392116638396

Clark, G., Russell, J., Enyeart, P., Gracia, B., Wessel, A., Jarmoskaite, I., Polioudakis, D., Stuart, Y., Gonzalez, T., MacKrell, A., Rodenbusch, S., Stovall, G. M., Beckham, J. T., Montgomery, M., Tasneem, T., Jones, J., Simmons, S., & Roux, S. (2016). Science educational outreach programs that benefit students and scientists. *PLOS Biology, 14*(2), Article e1002368. https://doi.org/10.1371/journal.pbio.1002368

Colwell, R. R., & Kelly, E. M. (1999). Science learning, science opportunity. *Science, 286*(5438), 237. https://doi.org/10.1126/science.286.5438.237

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE.

DeChenne, S. E., Enochs, L. G., & Needham, M. (2012). Science, technology, engineering, and mathematics graduate teaching assistants teaching self-efficacy. *Journal of the Scholarship of Teaching and Learning, 12*(4), 102–123. https://scholarworks.iu.edu/journals/index.php/josotl/article/view/2131

deKoven, A., & Trumbull, D. (2002). Science graduate students doing science outreach: Participation effects and perceived barriers to participation. *The Electronic Journal for Research in Science & Mathematics Education,* 7(1). https://ejrsme.icrsme.com/article/view/7696

Ecklund, E. H., James, S. A., & Lincoln, A. E. (2012). How academic biologists and physicists view science outreach. *PLoS ONE,* 7(5), Article e36240. https://doi.org/10.1371/journal.pone.0036240

Feldon, D. F., Peugh, J., Timmerman, B. E., Maher, M. A., Hurst, M., Strickland, D., Gilmore, J. A., & Stiegelmeyer, C. (2011). Graduate students' teaching experiences improve their methodological research skills. *Science, 333*(6045), 1037–1039. https://doi.org/10.1126/science.1204109

Fowler, D., & Cherrstrom, C. A. (2017). Graduate student perception of teaching development in a college teaching course. *NACTA Journal, 61*(2), 150–156. https://www.jstor.org/stable/90021196

Gaff, J. G., Pruitt-Logan, A. A., Weibl, R. A., & Participants in the Preparing Future Faculty Program. (2000). *Building the faculty we need: Colleges and universities working together*. Association of American Colleges and Universities. https://files.eric.ed.gov/fulltext/ED438764.pdf

Garibay, J. C. (2015). STEM students' social agency and views on working for social change: Are STEM disciplines developing socially and civically responsible students? *Journal of Research in Science Teaching, 52*(5), 610–632. https://doi.org/10.1002/tea.21203

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education, 25*(1), 99–125. https://doi.org/10.3102/0091732X025001099

Heinze, K. F., Allen, J. L., & Jacobsen, E. N. (1995). Encouraging tomorrow's chemists: University outreach program bringing hands-on experiments to local students. *Journal of Chemical Education, 72*(2), 167–169. https://doi.org/10.1021/ed072p167

Houck, J. D., Machamer, N. K., & Erickson, K. A. (2014). Graduate student outreach: Model of a one-day "chemistry camp" for elementary school students. *Journal of Chemical Education, 91*(10), 1606–1610. https://doi.org/10.1021/ed400617r

Kajfez, R. L., & Matusovich, H. M. (2017). Competence, autonomy, and relatedness as motivators of graduate teaching assistants. *Journal of Engineering Education, 106*(2), 245–272. https://doi.org/10.1002/jee.20167

Koehler, B. G., Park, L. Y., & Kaplan, L. J. (1999). Science for kids outreach programs: College students teaching science to elementary students and their parents. *Journal of Chemical Education, 76*(11), 1505–1509. https://doi.org/10.1021/ed076p1505

Komoroske, L. M., Hameed, S. O., Szoboszlai, A. I., Newsom, A. J., & Williams, S. L. (2015). A scientist's guide to achieving broader impacts through K-12 STEM collaboration. *Bioscience, 65*(3), 313–322. https://doi.org/10.1093/biosci/biu222

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. https://openjournals.libs.uga.edu/jheoe/article/view/933

Miles, M. B., Huberman, A. M., & Saldana, J. (2020). *Qualitative data analysis: A methods sourcebook* (4th ed.). Sage Publications.

Moskal, B., & Skokan, C. (2011). Supporting the K-12 classroom through university outreach. *Journal of Higher Education Outreach and Engagement, 15*(1), 53–75. https://openjournals.libs.uga.edu/jheoe/article/view/830

NASA. (2008, April). *Explanatory guide to the NASA Science Mission Directorate education & public outreach evaluation factors* (Version 3.0). Retrieved August 30, 2010, from http://science.nasa.gov/media/medialibrary/2010/03/31/SMD_EPO_Guide3_April08.pdf

National Science Foundation. (2003). *Merit review broader impacts criterion: Representative activities*. Retrieved August 30, 2010, from http://www.nsf.gov/pubs/2003/nsf032/bicexamples.pdf

O'Meara, K., & Jaeger, A. J. (2006). Preparing future faculty for community engagement: Barriers, facilitators, models, and recommendations. *Journal of Higher Education Outreach and Engagement, 11*(4), 3–26. https://openjournals.libs.uga.edu/jheoe/article/view/537

Prieto, L. R., & Altmaier, E. M. (1994). The relationship of prior training and previous teaching experience to self-efficacy among graduate teaching assistants. *Research in Higher Education, 35*(4), 481–497. https://doi.org/10.1007/BF02496384

Rao, S., Shamah, D., & Collay, R. (2007). Meaningful involvement of science undergraduates in K-12 outreach. *Journal of College Science Teaching, 36*(6), 54–58. http://www.jstor.org/stable/42992969

Rethman, C., Perry, J., Donaldson, J., Choi, D., & Erukhimova, T. (2020). Creating a physicist: The impact of informal/outreach programs on university student development (arXiv:2012.13981v2 [physics.ed-ph]). *Physical Review Physics Education Research, 17*, Article 020110. http://arxiv.org/abs/2012.13981

Robertson, J., & Bond, C. H. (2001). Experiences of the relation between teaching and research: What do academics value? *Higher Education Research & Development, 20*(1), 5–19. https://doi.org/10.1080/07924360120043612

Stryker, S. (1980). *Symbolic interactionism: A social structural version*. Benjamin-Cummings Publishing Company.

Thomas, G. (2011). A typology for the case study in social science following a review of definition, discourse, and structure. *Qualitative Inquiry, 17*(6), 511–521. http://journals.sagepub.com/doi/10.1177/1077800411409884

Walker, G. E. (2004). The Carnegie Initiative on the Doctorate: Creating stewards of the discipline. In D. H. Wulff, A. E. Austin, & Associates (Eds.), *Paths to the professoriate: Strategies for enriching the preparation of future faculty* (pp. 236–249). Jossey-Bass.

Weisbuch, R. (2004). Toward a responsive Ph.D.: New partnerships, paradigms, practices, and people. In D. H. Wulff, A. E. Austin, & Associates (Eds.), *Paths to the professoriate: Strategies for enriching the preparation of future faculty* (pp. 217–235). Jossey-Bass.

Wellnitz, T., MacRury, N., Child, A., & Benson, D. (2002). Spreading the wealth: Graduate students and educational outreach. *Conservation Biology, 16*(2), 560–563. http://www.jstor.org/stable/3061385

Yin, R. K. (2018). *Case study research and applications* (6th ed.). Sage.