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The Impact of a University-Based School Science Outreach Program on Graduate Student Participants' Career Paths and Professional Socialization

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Abstract

Drawing on professional socialization theory, this study examined how immersive experiences as science outreach educators in K-12 schools influenced the career paths and professional identities of science and engineering graduate students. Semi-structured interviews with 24 outreach program alumni revealed that school outreach experiences provided three important elements of professional socialization: specialized knowledge and skills needed to succeed in the profession; direct involvement with the profession's activities, colleagues, and personal meanings; and personal investment in the role and status of the profession. Outreach involvement exerted different patterns of influence on career paths. For some students, outreach participation confirmed career intentions, and provided knowledge and skills needed to succeed in the chosen path. For others, participation facilitated a change in career direction by providing low-risk opportunities to explore an alternate career and discover new career options.

Introduction

The role of science and engineering graduate students in university outreach and community engagement has received increased attention in the United States. Three parallel trends in higher education influence this heightened attention. First, within the science, technology, engineering, and mathematics (STEM) disciplines, national leaders have called on scientists to improve the quality of science education, and strengthen public science literacy by engaging with schools and citizens *(e.g., Alberts, 1991; Colwell & Kelly, 1999)*, and federal science agencies have incorporated this expectation into their granting mechanisms *(e.g., NSF, 2003; NASA, 2008)*. In response to these prompts, scientists and educators have developed programs and partnerships to reach children and adults, and universities and research institutes have established outreach offices and staff positions to carry out these activities *(Dolan, 2008; Franks, McDonnell, Peach, Simms, & Thorrold, 2006)*.

Concern about graduate education is a second relevant trend. Calls for graduate education to better respond to the needs of both doctoral students and society have issued from several quarters *(e.g., CPSMA, 2000; COSEPUP, 1995; Greene, Hardy, & Smith, 1996; Golde & Walker, 2006)*. Research documents gaps between the preparation that graduate students receive and the demands of their future careers *(Golde & Dore, 2001; Smith, Pedersen-Gallegos, & Riegle-Crumb, 2002; Nyquist et al., 1999)*. National initiatives recommend that graduate students have the opportunity to develop and recognize transferable skills, prepare for a variety of careers, and develop scholarly interests that address societal needs *(e.g., Gaff, Pruitt-Logan, & Weibl, 2000; Walker, 2004; Weisbuch, 2004)*. For future faculty, this includes preparing for teaching and outreach roles as well as for research and creative work.

A third trend is the movement surrounding community engagement of universities. As traced by Sandmann *(2008)*, the notion of "engagement" was initially a reframing of how universities could meet historical commitments to society. Campus leaders called for bidirectional reciprocity in universities' work with communities, rather than one-way extension of university resources from "gown to town." Recognizing that, to succeed, this commitment must also align with faculty values and university rewards systems, scholars and leaders have articulated a vision for outreach and engagement as scholarly expression that integrates research, teaching, and service.

To date, little attention has been given to how these three developments may join forces. As O'Meara and Jaeger *(2006)* point out, links between national conversations about higher education's public mission and graduate education have been inadequate. Nonetheless, they note, graduate students' involvement in outreach and engagement promotes their professional growth as they learn skills, deepen and apply their knowledge, and make meaningful connections. Further, the university is obligated to prepare faculty and students to carry out its civic mission. Yet the research focus of universities where most graduate education is conducted tends to privilege individualism over collaboration, specialization over breadth, and basic over applied research *(O'Meara & Jaeger, 2006)*. Faculty reward structures emphasize research and external funding over other paths to excellence, sending conflicting messages about the importance of the university's public mission. As graduate students are socialized in this environment, these values are thus perpetuated.

A decade ago, these three trends converged in the National Science Foundation's (NSF's) Graduate Teaching Fellows in K-12 Education program (GK-12 program). The GK-12 program aimed to help graduate students acquire professional skills; to enhance STEM learning and instruction in schools; to strengthen and sustain partnerships between K-12 and STEM higher education; and to make these activities routine *(NSF, 2007)* Thus, the intent was not just to support the education of individuals, but to have lasting institutional impact on both university-community collaboration and STEM graduate education. GK-12 projects have documented benefits to graduate fellows, K-12 teachers, and schoolchildren *(Gilmer, Granger, & Butler, 2005; Mitchell et al., 2003; Stamp & O'Brien, 2005; Thompson, Collins, Metzgar, Joeston, & Shepherd, 2002; Trautmann & Krasny, 2006)*. But whether GK-12 programs have made a lasting impact on their institutions or on patterns of graduate education is unknown. Also of interest is the longer-term impact on graduate student participants: How does this experience change their career outlook and career choices? For those who later become faculty, what is the influence on their practices in teaching, outreach, or mentoring of graduate students?

In this article, the authors consider the convergence of these disciplinary, educational, and public service goals in a university outreach program that offers science education enrichment to K-12 students through classroom visits by trained science and engineering graduate students. The study examines both short-term outcomes of graduate students' participation in the outreach program, and the influence of participation on their later career trajectories. Drawing on professional socialization theory, the authors show how the outreach program socializes graduate students into teaching and engagement roles for scientists that were not otherwise available in their degree programs. In contrast to most studies of graduate student socialization, which focus on formal degree programs, this study examines an extra-departmental program.

Conceptual Framework

As theoretical underpinning, the authors looked to the framework of Weidman, Twale, and Stein *(2001)* on graduate student socialization, based on Thornton and Nardi's framework for role acquisition *(1975)*. Professional socialization includes development of the knowledge, skills, beliefs, and values that prepare new Ph.D.s to enter the profession *(Weidman et al., 2001)*. Individuals learn not only the formal policies and rules of their profession, but

also shared informal expectations and norms *(Schutz, 1970)*. Thus professional socialization is a "ritualized process that involves the transmission of culture" *(Tierney & Rhoads, 1993, p. 21)*; a two-way, adaptive process by which both individuals and the profession are influenced.

Through socialization processes, science graduate students are enculturated into their disciplines, the values shared by their specific fields and academic work at large, and the broader values of science, which bear upon their persistence, success, and career outcomes. Weidman and colleagues *(2001; Weidman & Stein, 2003)* describe three core elements of graduate socialization: (1) acquisition of knowledge and skills; (2) involvement in the professional role as a practicing novice; and (3) investment, which includes commitment to the role, adoption of its expectations, and professional sponsorship. Cognitive dimensions of the professional role—knowledge and skills—may be transmitted through formal instruction and are often explicit in departmental goals, while affective and integrative dimensions are more implicit and are transmitted through informal processes such as interpersonal interactions and general climate.

Antony *(2003)* criticizes socialization theory for the assumption that, to succeed, an individual must adopt the profession's norms and values—perhaps replacing her own. He argues that compliance with a narrow set of professional norms is not required for socialization to benefit the individual and the profession. He gives the example of a group of African American doctoral students who had mastered knowledge and skills in their field: students who continued to pursue an academic career had learned "how to navigate the normative expectations of the field without co-opting their own values," while

> those students who were socialized to believe that the field's norms and values needed to be adopted in order to succeed felt a great amount of cognitive and emotional dissonance. This ultimately led these students to assume that an academic career was not for them, and that the personal sacrifices one needed to make in order to attain an academic career were insurmountable and unacceptable. *(p. 374)*

An Outreach Program That Has an Impact on the Professional Development of Graduate Students

This section describes an outreach program as background for its role in graduate student career preparation. The Science Squad is sponsored by the Biological Sciences Initiative, an externally funded outreach program at the University of Colorado Boulder. Each year the Science Squad consists of four to six graduate students from STEM fields related to biomedical science, who visit K-12 school classrooms to lead inquiry-based science lessons.

Selected in a rigorous application process, the graduate students participate in the Science Squad instead of working as teaching assistants, while continuing their dissertation research. Each member works with program staff to create four presentations in his or her scientific field that emphasize hands-on, inquiry-based activities consistent with current best practices in science instruction *(Olson & Loucks-Horsley, 2000)*. Because the presentations are short in duration and offered to a range of grades, schools, and school districts, they are not aligned to any single curriculum or set of district standards, but in practice teachers match them to their classroom learning goals through their topical and scheduling choices *(Laursen, Liston, Thiry, Sheff, & Coates, 2004)*. Program advertising specifies the range of grade levels suited to each presentation, and members are coached on how to modify the presentations to meet different developmental levels.

Throughout the school year, Science Squad members typically offer these presentations two days a week, usually visiting several classes at one school each day. Thus the program provides both an intensive teaching experience to Science Squad members and a science enrichment experience for about 15,000 K-12 students and 270 teachers annually. Seeking to encourage minority students and girls to enter science, Science Squad members prioritize underserved schools, typically reaching a population that is 46% minority and 56% female. Science Squad members are selected to serve as role models for all students, and many teachers explicitly use the program with that aim.

From its conception in 1990, the Science Squad was viewed as outreach to local K-12 schools, antedating both the GK-12 program and Boyer's *(1990, 1996)* articulation of "engagement" as scholarly application of university expertise to community needs. Yet the Science Squad offers strong mutual benefit to both the school and university participants, consistent with the bidirectional reciprocity

implied by the term "engagement" *(Sandmann, 2008)*. Further details about the program are given elsewhere *(Laursen, Liston, Thiry & Graf, 2007; Laursen et al., 2004; Laursen, Thiry, & Liston, 2005)*.

Assessing the Impact of Science Squad Participation on Graduate Students

This study sought to assess the positive or negative outcomes to Science Squad members of participating in the Science Squad, and to understand how these outcomes arose. Based on anecdotal evidence and on literature suggesting that teaching skills and interests are often undersupported in graduate school *(Golde & Dore, 2001; Smith et al., 2002)*, the authors were particularly interested in the role of Science Squad in socialization, and how immediate outcomes, such as growth in knowledge or skills, might influence participants' later career interests, decision making, and success. A qualitative interview approach was chosen to explore program outcomes and processes broadly. Retrospective sampling enabled participants to reflect on how their careers had or had not been influenced by participation.

The study procedures were approved by the University of Colorado at Boulder Human Research Committee. As external evaluators, the authors were not responsible for running the Science Squad and had no stake in the program outcomes. They consulted with the program developers about the program's design, history, and hypothesized or desired outcomes.

Study Participants

The sample of Science Squad members was drawn from a total of 34 alumni participants between 1992 and 2002. The researchers located contact information for 28 of these, and interviewed the 24 alumni who responded, during 2003–2004. Given the time span of participation, the interviews captured both recent and longer-term, retrospective views. The program was stable in organization, and alumni from different years reported similar activities and outcomes. Members recalled a surprising level of detail and traced aspects of their current careers back to their time in the Science Squad. Thus, despite time variations, corroboration among members' reports lends validity to the findings.

The sample of 20 women and four men reflects the historical gender makeup of the program. Most members were white. However, as two male interviewees were Latino, 22 of 24 interviewees were from gender or ethnic groups generally

underrepresented in science. Combinations of individual demographic details are omitted to protect confidentiality.

Members from biology, anthropology, engineering, and geography departments participated for one to six semesters; multiyear participation contributes to the low total head count despite the 10-year span of the sample. Most members joined the Science Squad as graduate students; a few were postbaccalaureate or postdoctoral scientists. All expressed high initial interest in teaching; many had prior experience with youth in informal and experiential education. Members were motivated to join by their enjoyment of teaching and desire to improve their teaching skills; by altruistic reasons; by a desire for a change of pace from their research work; and by a need for financial support for their graduate studies, though none reported funding as a sole motivation.

Data Collection

Semi-structured, in-depth interviews were guided by an ethnographic approach grounded in methodological traditions from sociology, anthropology, and social psychology. Members described their current career situation and, retrospectively, their participation in the Science Squad and its relation to their graduate studies. Science Squad members described their education and career paths and career decision-making processes. Interviewers probed how Science Squad members perceived the benefits to themselves, students, and teachers in the program; their evidence for these benefits; and how these were achieved. In addition, the interviewers asked about participants' motivations to join the program and their experiences with it, including difficulties or costs, and invited their advice to program staff. The protocols were flexible to enable following up on interviewees' comments; later interviews incorporated some new issues that emerged in earlier interviews. Interviews of 45–70 minutes were conducted by two interviewers, most often by telephone; they were recorded and transcribed verbatim. Laursen et al. *(2007)* report findings on student and teacher benefits, including data from separate teacher interviews.

Data Analysis

Two approaches to data analysis were used. First, short-term outcomes of Science Squad participation were analyzed using simple thematic coding, as detailed in Laursen et al. *(2007).* Second, to analyze Squad members' career paths, the emphasis of this article, a narrative inquiry approach was applied. This approach focuses on

the stories respondents tell to make sense of their experiences, and recognizes that people construct and interpret past events to "create a plot from disordered experience" *(Riessman, 1993)*. Although interviewees did not typically reveal their educational and career path in strict chronological order, the authors reconstructed a "career narrative" from each interview by gathering and re-sequencing all career-related observations. For many respondents, the resulting narrative included detailed accounts of their career paths and the reasoning behind their choices, including current thinking and retrospective statements about past intentions.

Each career narrative was then divided into short segments identifying key decision points and career-related intentions or actions. By aligning these segments according to temporal and thematic commonalities, similarities and differences in decision points and actions could be discerned across the set of narratives. The authors could identify patterns in the sequence of events, attribution of cause and effect, or results of decision-making. These commonalities often became apparent only after examining the narratives in matrix form, where shared patterns of change appeared in how a career choice emerged from individuals' otherwise varied accounts of their career trajectories.

Member checks were conducted during interviews, when interviewees were asked to respond to points made by others, and by e-mail follow-up, when respondents were invited to comment on a summary of the study findings and offered copies of the reports and publications. Several respondents validated the findings or expanded on some points from their own experience; none disputed any conclusions.

Findings

Data analysis focused on the elements and processes of professional socialization that affected the career paths of Science Squad alumni. In addition to the knowledge, skills, and beliefs gained from Science Squad participation, these socialization elements include the norms and values communicated to participants by faculty and peers in their departments. In this section, the authors

- report the career-related benefits of participation in the Science Squad as identified by participants themselves;
- describe values and beliefs communicated by departmental faculty members and peers to Science Squad members;

- report participants' career outcomes; and
- describe the influence of Science Squad participation on the graduate students' career paths.

Career-Related Benefits of Participation in the Science Squad

Members reported several outcomes of their participation in the Science Squad *(Laursen et al., 2007)*. This report emphasizes the career relevance of these gains as socialization outcomes. At least 20 of the 24 interviewees reported gains in each of four categories:

1. Teaching, communication, and management skills
2. Understanding of issues related to education and its social context
3. Personal development
4. Career skills

Teaching, communication, and management skills.

Participants reported considerable gains in teaching skills, which they viewed as valuable both for educators and for other professions requiring scientific communication. In explaining scientific ideas to varied audiences, members strengthened their own conceptual understanding and learned to make impromptu adjustments to meet audience needs. Participants reported learning to use interactive, inquiry-based teaching approaches; gained practical skills in lesson planning, materials selection, and classroom management; and began to develop an individual philosophy and style of teaching. One participant, now a middle school teacher, commented,

> Going into a new classroom every time . . . I learned a variety of ways to keep the kids on task and directed, . . . a lot of ways to present different ideas, to try to reach as many kids as possible. So I think it helped me figure out what my teaching style was. It shaped what my management style was going to be. . . . And that's definitely how I try to run my classroom now, doing a lot more inquiry-based [teaching]—rather than lecturing or just talking to the kids, letting them figure out stuff on their own.

The process by which participants developed these skills also made the skills transferable. Repeating and refining a presentation under varying conditions built strong, general teaching skills that could be applied later at the K-12 or university level. The chance to "try the same package again and again, to just try different angles" yielded more feedback and faster improvement than teaching a course once a year. Other school- and university-based activities also fostered growth: observing classrooms; interacting with teachers over lunch; troubleshooting and debriefing with Science Squad colleagues; and individual coaching and conversing with Biological Sciences Initiative staff in monthly meetings. These activities combined experiential learning with opportunities to reflect.

Science Squad members described how these gains applied broadly in their later work. One attributed her high university course evaluations to teaching skills honed on the Science Squad; an outreach professional described her success in "translating science in the Science Squad spirit." Outside the classroom, participants used similar approaches to help people understand science that affected their daily lives, as this environmental engineer commented:

> Sometimes I get to go to homeowners' meetings and explain what our engineering project is going to do. . . . I think it's incredibly important that I don't use jargon, that I can communicate to normal people about their water or their wastewater. . . . These are people who aren't as schooled in engineering as you are . . . [so] how best can you explain this or help them discover, by you leading them on to think along a certain path?

Understanding of education in context.

A second type of benefit reported by Science Squad members was growth in understanding education and its social context: student learning and development; inequities in educational access; the articulation between K-12 and higher education; and the work of teachers and schools. Gains in understanding came through working with diverse populations of students and teachers. Previously, said one member, now a college professor, "I didn't realize the implications of cultural differences in the classroom . . . how those issues could impact day-to-day classroom activities." She gave a specific example of realizing a certain classroom behavior

was not just a trait of a "good" student but culturally shaped, so she had learned "not to attach so much to that behavior, and those expectations."

Some gained a more comprehensive view of education as a system. Visiting so many schools, one member noted, "I learned a lot about what makes schools work and what makes them not work; why one teacher is enjoying their job and another one isn't." This had practical benefit, giving her "better questions to ask" in job interviews. An outreach specialist described how knowledge of schools helped her to design effective programs.

Personal development.

Personal gains included growth in confidence and intrinsic rewards of feeling that one's work benefits others. Confidence gains were not general gains in self-esteem, but specific to the work at hand—confidence to communicate science to others, manage a classroom, or "see myself as a scientist"—thus providing assurance and opening up new possibilities for future careers. "I was absolutely comfortable going into any teaching situation and being able to teach—I mean, just off the top of my head without being familiar with the students or the setup," said one member of her faculty job interviews.

Many members also reported intrinsic emotional benefits—"warm fuzzies," as one put it. They valued collegial relationships with their Science Squad cohort and the Biological Sciences Initiative staff, and felt gratified to see students learning and enjoying science.

> It was a big traveling experiment, and kids lit up. And kids would come up after class and they'd say "Oh, man . . . we've been in here for a year and we've never done three days of experiments just like that." They were like, "I can't believe science is so fun. I hated this until you." [laughs] . . . Every now and then everybody needs some sort of positive feedback about what kind of a human being they are.

Sometimes these emotional benefits made up for the "humbling experience" of graduate school. "It was a nice antidote to the lab, where everyone gets judged by their publications and their productivity," said one member. "It's kind of nice to see . . . some excitement, and awe."

Career skills.

Finally, Science Squad members who had entered careers at the time of the interview (about two thirds of the sample) described concrete career benefits. Some carried specific career resources to their jobs: they reused teaching materials, disseminated innovative lessons, and used their networks to establish new outreach programs. Job search benefits included enhanced résumés and interviewing skills, and a greater ability to evaluate job opportunities. Those seeking faculty positions found that Science Squad experience was taken to prove their aptitude and interest in teaching.

> I think [Science Squad] figured favorably in my being hired. . . . People took it to mean that I was interested in . . . in being part of a community rather than just at a university. . . . And I think that's how I couched it, that not only had I done work within the strict confines of jobs that I had held, but I had also tried to . . . use my education in other ways.

Cumulatively, Science Squad experience amounted to an intensive teaching practicum, where members could develop and apply their ideas in real teaching situations, then analyze and discuss them afterward. Members gained knowledge and skills that helped them to work effectively both during Science Squad service and in their later careers. Their personal and emotional gains—confidence as science teachers, pride and pleasure in their work—reflect a growing sense of identity as teaching professionals. Together, these gains addressed both cognitive and affective elements of socialization, through mechanisms including formal training, experiential learning, and observation of other professionals.

Departmental Context: Responses from Faculty and Peers to Science Squad Involvement

Science Squad members reported only a few negative aspects to their outreach participation: difficulties with time, travel, and organization in getting to schools *(Laursen et al., 2007)*. More relevant to socialization were negative responses to their Science Squad participation from graduate advisors, other faculty, or peers in their departments, examples of which were reported by 19 of 24 interviewees. Members described receiving both overt and implicit messages that teaching was lower in status than research, and that K-12 teaching was even lower than university teaching, and they

perceived that some colleagues neither understood nor valued their choices *(Thiry, Laursen, & Liston, 2007)*.

Negative reactions from peers and other faculty have primarily emotional impact, because these people have only indirect roles in a student's career development. But research advisors play a crucial, gatekeeping role in dissertation and career progress *(Fox, 2000, 2003; Lovitts, 2001)*. Thirteen Science Squad members described their research advisor as generally supportive of their plans, and eight said their research advisor was negative about either Science Squad participation or its longer term career implications. Seventeen members described negative reactions from other faculty or peers.

The most supportive advisors were described as backing their students' individual decisions about career and educational goals, whether or not they agreed with them.

> I knew people in my department who were like, "Yeah, sounds really cool, but there's no way I'd be able to do it." Not because, personally, they couldn't do it, but because they wouldn't be allowed to do it, which is kind of a shame. . . . I happened to be fortunate enough to work with somebody who was a little more lenient and flexible with my particular education plan.

Many advisors raised concerns about the time commitment of joining the Science Squad. Supportive advisors might bring up legitimate concerns about time management or research progress, but were perceived to value outreach, to understand their student's interest, and to weigh its merits against short-term costs of participation. Such views were seen as exceptional.

> He said, "Do what you want to do, but you know it's not gonna help you get done any sooner." [laughs] I mean, he supports me as a person, fortunately. He's a little different than most of the people in my field. But he said he had concerns about it interfering with my work, and me getting done in a timely manner—my degree taking five years instead of four.

In contrast, non-supportive advisors were perceived to value research time over any potential benefits of outreach to the participant or to society at large. While advisors' overt statements addressed time concerns, members heard a covert message that working on the Science Squad was a distraction from the real work of research.

> Member: I think he thought it would be a drag on my time, and my job was really to do my lab work and write my thesis. And I saw it as very much in line with my overall preparation, and I don't think this time detracted from my lab work or writing my thesis.
>
> Interviewer: But it sounds like, overall, your advisor had a somewhat negative impression of the Science Squad?
>
> Member: I think he'd have a negative impression of anything that took me outside the engineering building.

Science Squad members perceived some department members as indifferent to their career goals. Noted one, "They were training me to be a researcher and that's what was interesting and . . . that was pretty much it." Others felt their seriousness was questioned: "I think there are several professors that probably think it's the ones that aren't good enough to make it in science that would do Science Squad."

But not all departmental reactions were negative. In departments where funding was scarce, the Science Squad assistantships were prestigious. Some colleagues valued members' efforts to communicate their discipline: "They appreciated that kids out in the world were getting some botany. . . . It doesn't show up on TV a whole lot." Most scientists are glad to see "kids get excited about science," said another—they don't "want to be bothered with a bunch of zoo-ey high school kids, but they're fine if other people want to." Others saw advisors' views become more positive as they learned about the program and saw it benefiting their advisee—a reminder that socialization is bidirectional, such that graduate students can influence their departments as well as vice versa *(Weidman et al., 2001)*.

Whether or not members' perceptions are accurate records of actual faculty views is not the point. Rather, the data illustrate how interpersonal interactions and departmental climate contribute to graduate student socialization. Our interviewees understood messages from department members about the value of teaching and outreach—positive, negative, or indifferent. They had already reflected on and interpreted these messages, and in some cases acted in response to them: Few were surprised when the interviewer asked about others' response to their outreach activity. When students joined the Science Squad, the "informal or hidden

role expectations which 'arise and are transmitted by interactions with others'" became more visible *(Antony, 2003, p. 361, citing Thornton & Nardi, 1975)*.

Career Outcomes Reported by Science Squad Participants

Data on career outcomes reflect varying intervals after participation in the Science Squad, with a larger number of participants from later years. Early participants had established careers, while more recent participants were in postdoctoral or other temporary positions, or were still completing graduate training. Despite this variability, patterns emerged. First, Science Squad members were highly trained in science. At the time of the interview, 19 of 24 interviewees held or were completing a Ph.D. in science or engineering, and four more had pursued other advanced degrees in scientific or technical fields (M.S., M.D., M.P.H.). No Science Squad member had "left science." Each of the 24 worked in a science- or engineering-related field, although two were unemployed at the time of the interviews.

Second, many Science Squad members were employed as educators. Of 24 interviewees, eight worked in higher education (five in tenure-track positions), and six worked with K-12 education as science outreach educators, teachers, or professional tutors. This represents 58% of the total sample, and 82% of those who had completed their graduate training. This is well above the national proportion of graduate-trained life scientists (28%) who cite teaching as their primary work activity *(NSF, 2006)*. Table 1 shows the initial career outcomes of interviewees, grouped by career type.

Table 1: Initial Career Outcomes of Science Squad Interviewees (reported in 2004)

Career in higher education (n = 8)	Career in K-12 education or outreach (n = 6)	Completing training, planning career (n = 7)	Other or undetermined careers (n = 3)
Tenure-track teaching position = 5	Outreach professional = 4	Tenure-track position in higher education = 3	Work outside education = 1
Non-tenure teaching position = 3	K-12 teacher or tutor = 2	K-12 education or outreach position = 2	Unemployed = 2
		Work outside education = 2	

As described in a previous section, Science Squad members encountered the expectation that working with K-12 education would derail their careers and deny them prestigious tenure-track academic positions. This expectation was unfounded, as 29% of Science Squad members who had completed their education became tenure-track faculty members, a proportion indistinguishable from the percentage (32%) of all biological science Ph.D.s who became tenure-track faculty in the same period *(NSF, 2001)*. Their choices of faculty positions, however, did emphasize education, as the quotations below illustrate.

> My first focus is the subject matter, and then my second focus is, I really enjoy communicating it with people. And so I have decided to take a job that is 60% teaching, and that fits me very well.

> I would ideally like to get a tenure-track position at a school that's primarily undergraduate teaching, but where I can do research with my undergraduates, and still do some publishing. But not a Tier 1 research university, where it's a pressure-cooker state, "publish or perish" situation. . . . Doesn't really fit my personality.

The desire to combine multiple interests was common in members' career aspirations, as reflected in their integrative language.

> [My position involves] a blend of teaching and research, so that the faculty here who have tenure-track jobs are evaluated on their teaching first, the research second, and then their service—and they're all excellent teachers here. But they do have time to do research and they do get a lot of research done. It's a nice mix.

> I chose [this university] because . . . there was already outreach work going on here. And I think that's important to give back into the community, and because they value that—they value the balance, and the person.

Several Science Squad alumni who became college faculty had specialized in teaching non-science majors. "I teach introductory environmental science now, because I'm good at it," one reported. "They want to attract majors; they don't let people who don't have

any teaching skills teach this course." Others incorporated outreach into their faculty work, promoting science to young people, or recruiting minority high school students into science.

> Volunteerism is important to me. And I choose my volunteerism to look like outreach to kids, 'cause that's what I enjoy. . . . Most of those students didn't even know what an engineer was . . . and had no concept of that as something that they could become—let alone a scientist or biologist or whatever. It's important for students to have those role models, and to understand that there are opportunities.

Like the college educators, the K-12 educators had chosen positions where they "could make a difference." One chose to teach middle school, where students commonly lose interest in science. Another chose "the worst-performing school in the state . . . that could be shut down at any day." Members outside education also cited the career relevance of their educational interests.

In 2010, the authors followed up with interviewees using internet searches and e-mail. They positively identified each study participant, and determined their current or recent (within 12 months) career status. Figure 1 compares the 2004 distribution of careers with the 2010 distribution.

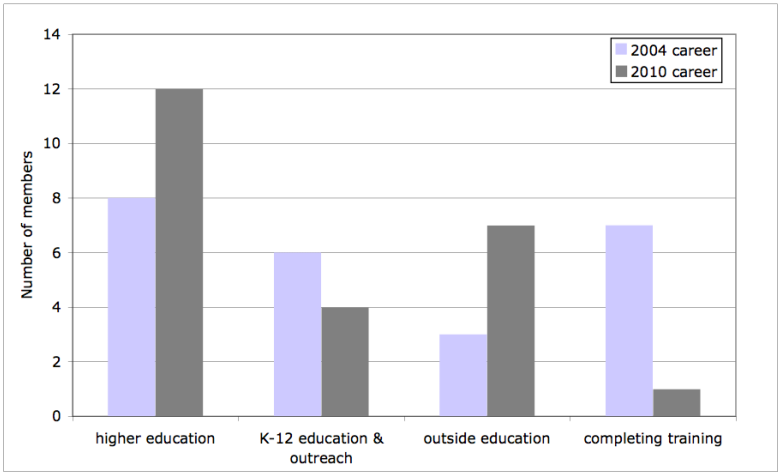

Figure 1: Career Outcomes for Science Squad Alumni, 2004 and 2010

From the 2010 data, the authors drew several conclusions.

- **Predicted educational paths were largely stable.** Of the seven still pursuing training in 2004, all had finished their degrees (including three Ph.D.s, one M.P.H., one M.D.). Two postdocs had acquired permanent positions. One had taken a third postdoctoral research position, and another had returned to school to earn a doctorate of pharmacy.
- **Persistence in science or engineering careers continued from 2004 to 2010.** In 2010, only three of the 24 alumni were now in non-science careers, including jewelry designer, fitness coach, and writer.
- **Work in education careers also persisted from 2004 to 2010.** In 2010, 18 alumni worked in K-12 or higher educational organizations. Sixteen held positions that involved some teaching. Non-education careers included physician, pharmacist, and engineer.
- **Science Squad alumni who sought tenure-track positions in higher education had them.** In 2010, seven (29%) were in tenured or tenurable positions. Of the others in higher education, two held teaching positions with employment security; two were instructors with renewable contracts; and one was a university research administrator. Between 2004 and 2010, one participant had left a tenure-track faculty post for a non-tenure-track instructorship.
- **Some career changes did occur.** Family and personal considerations were prominent explanations by those who made career changes. But nine of 17 Science Squad alumni who had entered careers in 2004 were still in the same careers or positions in 2010.

In sum, across the sample and over time, a strong commitment to education is evident in participants' career choices. Joining the Science Squad did not initiate interest in education, but, by their own reports, had reinforced members' interest, built professional skills, and amplified the importance of education in their careers.

Influence of Science Squad Participation on the Graduate Students' Career Paths

Comparison of the "plot lines" of Science Squad members' career paths showed relationships among life events, their career consequences, and participants' explanations of their decisions. These relationships helped reveal whether and how participation in the Science Squad influenced career decision-making. Two significant patterns of influence together apply to most of the participants in the sample.

The "Strategists": Confirmation and Enhancement of an Existing Career Path

One pattern appeared in the career paths of nine Science Squad members, denoted the "strategists." For these nine, Science Squad participation confirmed their current career path and enhanced their preparation for the intended career. They entered graduate school with a particular career goal and used the Science Squad experience strategically to reinforce and validate their original career plans, build skill sets, and enhance résumés.

Most strategists entered graduate school planning to pursue teaching and research as faculty members. These goals were in some ways normative for science Ph.D. students, but less so in their emphasis on teaching-oriented institutions. Consistent with their plans, the strategists succeeded in obtaining faculty posts. Of the nine strategists, six were in tenure-track positions or seeking them from postdoctoral positions. A seventh was still in school, and two (a K-12 teacher and an engineer) did not want tenure-track positions.

This group is "strategic" because they anticipated in advance, and valued in retrospect, the ways that Science Squad experience furthered their career development. "I think the Science Squad got me the set of interviews I got," said one. "I thought at the time it would be, and I think it did prove to be more valuable to me in my career goals." Forethought is evident in their language.

> I was unsure whether I'd be able to explain scientific topics to non-science people . . . and I really thought it was an important skill. And I really had to fight my advisor on that—he was like, "Oh, nobody'll care." . . . But I think it's important, and I think that it helps me do a better job in my job.

> I thought, "Well yeah, Science Squad sounds like a neat way to turn, to get a bigger, a broader diversity of teaching experience—interact with people with all kinds of different backgrounds, different ethnic and racial backgrounds, different educational experiences, small schools, big schools, inner city, suburban. . . . And you know, it'll look good on my résumé to have done some more different things."

Though members anticipated benefits, in no case were their motivations strictly instrumental. Genuine interest in teaching and a desire to serve the community were widely expressed, co-existing with a pattern of strategic thinking about how Science Squad could help them to achieve multiple goals. Consistent with these aims, the strategists joined the Science Squad late in their graduate careers, after they were independent in research and preparing to finish their degrees, which all did. Most participated for only 1 year. Although the intrinsic benefits of participation were ongoing, a year of experience supplied the desired skills and résumé enhancement, but longer involvement would offer diminishing returns and possible risk, as this speaker suggested.

> If I went through my graduate program having taught primarily for the Science Squad, I don't think I would have been able to obtain the job [I have now]. . . . [T]hey would have said, "Well, okay, he's got all this research, but he's been teaching high school level." . . . Those things were not going to be rewarded and they're not rewarded still.

The "Seekers": Clarification and Change

The second type of career influence was more dramatic: For 11 of 24 interviewees, serving on the Science Squad stimulated clarification and change of career path. Science Squad experience opened, closed, or clarified career options under consideration. Because they often used the Science Squad to explore career possibilities, these members are termed the "seekers."

Like the strategists, most of the seekers entered graduate school with a specific career goal: "I was going to be a professor. I don't think I'd narrowed it down [to] a research institution or a liberal arts institution, but I definitely had this image of myself being a professor." But when they joined the Science Squad, they were

actively reconsidering their initial plan. Some were deterred by the work environment or lifestyle they saw as accompanying an academic career, while others recognized a lack of fit to their own strengths. "It was very clear to me after my . . . postdoc that I hated research, but what was completely unclear to me was what I wanted to do instead. And this was a big black hole mystery."

For the seekers, joining the Science Squad was a low-risk opportunity to explore a career alternative in teaching: "I was interested in seeing what it would be like to teach in schools, and Science Squad enabled me to do that without going to do a teaching degree," said one. As members' language reflects, the opportunity to explore was timely.

> I still was reluctant to give up the research academic track, so I decided . . . that I would basically take a year . . . and do the Science Squad . . . and spend the rest of my time looking at what opportunities were out there. And by the end of that year, I realized that I was actually very happy doing outreach work, and that I was okay with giving up the academic research path and devoting myself to a different career path instead.

The crucial pattern among the "seekers" is their growing dissatisfaction with previous career plans together with their use of Science Squad to explore another option. Demographic patterns also distinguish seekers from strategists. At the time of the interviews, seven of 11 were in early stages of graduate work, and fewer eventually completed a Ph.D. Their career questions arose early and prompted exploration before they committed more time to graduate study, so they adjusted their educational path if a doctorate was not needed for their new career goals.

Factors influencing seekers' search for alternate careers.

As they considered careers, seekers reported a mix of "pushes" away from research, "pulls" toward teaching, and geographic and family considerations: "I really liked the topics that I was studying, but it wasn't compelling enough to be my lifelong career . . . Science Squad just fit with my goals, and also my abilities." Another member shared a list of well-defined reasons for leaving research, but had many remaining questions: "I knew I liked the teaching much better than the research. That was very clear. But where I was gonna teach, how I was gonna teach, whether teaching was really it,

wasn't clear." She could draw on ample experience to evaluate her fit to a research career, but had little basis for evaluating teaching careers.

Science Squad experience also prompted reflection on personal aptitudes and preferences.

> I think I realized in some ways how unhappy I was in my graduate program by doing the Science Squad. I realized that I could do something that was work and have fun doing it and really be excited about it and have a passion for what I was doing, that I had sort of lost in the midst of doing my Ph.D. research.

> What I recognized, partially through my experience, was that I wasn't interested in pursuing an academic career in a university, as a tenure-track faculty. And so, subsequent to being in the Science Squad, then I made different choices—I mean originally, I had been in the program to get a Ph.D. After being in the Science Squad, I realized I didn't have any interest in finishing a Ph.D. I knew that I liked outreach programming a lot more than I liked academic science, and so that gave me the clarity to understand that I needed to finish with a Masters and pursue my interests in a different way. So, you know, again, I don't think that my—it wasn't due to the Science Squad, it was just me recognizing something about myself.

This speaker's comment shows that the influence of Science Squad in her career thinking was not one of simple cause and effect. Already disinclined toward the academic careers promoted in her department, she was able to discern her preferences by contrasting Science Squad work with research. Such reflection was common among our interviewees.

For seven of 11 seekers, Science Squad participation clarified their career options in a positive way, showing them new career paths. Four alumni moved into professional outreach roles. By observing the Biological Sciences Initiative staff, they had seen that scientists could earn a living as educators, "doing good work and . . . using their Ph.D.s well." A fifth person became a middle school teacher: "In the first two months, I decided that I definitely wanted to get in the classroom. . . . [Then] it really helped me narrow down exactly where I wanted to teach." Two, still in graduate school, were

considering college teaching or professional outreach as well as research careers; both testified that the former were new career ideas spurred by Science Squad participation.

The other four Science Squad members reported negative clarification, as each ruled out a career in K-12 teaching, based on firsthand experience. This was not a poor outcome, but useful knowledge for the individual, from which other career ideas might emerge.

> I give those people [high school teachers] a lot of credit, but I couldn't do it again. . . . Working with teachers is a better level for me.

> It helped me decide that I don't have any interest in being a middle school or high school teacher . . . something that I had kind of contemplated [earlier]. . . . But it also made me much more comfortable with teaching in general, and so more interested in maybe teaching at the college level, which I hadn't given as much thought to before.

Again, both pushes away from and pulls toward careers were evident in members' reasoning. One member was attracted to teaching as seemingly more family-friendly than research, but did not find teaching a good fit. Exposure to school realities—"I was overwhelmed more than inspired"—led another to reject a career in K-12 teaching. Trying it out had settled the matter and set her on an alternate path toward a now-tenured faculty career.

Other Science Squad Members: Also Benefiting

In different ways, both strategists and seekers took active advantage of the Science Squad to proactively explore career options and develop expertise in their chosen paths *(Thiry et al., 2007)*. In addition to the nine strategists and 11 seekers, four Science Squad members reported career benefits, but no particular influence on their career path. There is no reason to expect that everyone's career path will be influenced by participation—indeed, it is remarkable that so many were.

Discussion

From this study, the authors conclude that Science Squad participation helped to socialize members as scientist-educators

in multiple ways. They gained knowledge, skills, and beliefs that enhanced their professional preparation. Their participation also provoked responses from departmental peers and faculty that communicated disciplinary values and norms associated with this career path. For some, Science Squad participation provided socialization into the practices of scholarly engagement as university faculty. Each of these socialization processes is discussed below.

Socialization of Graduate Students into the Professional Role of Scientist as Educator

Graduate students are simultaneously socialized into the role of graduate student, the academic profession, and a specific discipline or field *(Austin & McDaniels, 2006)*. Here we refer to socialization into the profession of scientist. These interviewees had pursued graduate education driven by their interest in science or engineering; most remained in these fields. Teaching let them share their enthusiasm for science, develop skills, combine multiple interests, encounter new places and people, and "give back" to their communities. As interviewees traced their journeys through graduate school and the Science Squad, the question with which they grappled was whether the role definition of scientist could encompass primary work in science education.

Their journeys can be interpreted in terms of socialization theory, as outreach participation provided all three elements of professional socialization identified by Weidman et al. *(2001)*. Becoming a Science Squad member was an intensive experience of *involvement* in the professional role of scientist as educator. Science Squad members took on real and meaningful responsibilities and interacted with other science education professionals as colleagues. In the schools, each represented her or his discipline to pupils and teachers. As Weidman and colleagues note, professional role identification arises from involvement in the role and thinking about the personal meaning of participation in that role.

Through a combination of training, collegial conversation, and immersive experience, Science Squad members reported substantial *acquisition of knowledge* and skills relevant to scientific careers in or out of education. Novices must develop the cognitive knowledge and skills needed to perform a professional role *(Weidman et al., 2001)*—thus this element of socialization is entwined with involvement. They must also develop affective knowledge, such as awareness of norms for the role and realistic self-assessment of their own ability to perform it. Science Squad members' reports emphasize cognitive knowledge and skill gains, but their statements

about confidence and reward also indicate affective knowledge gains, including both self-awareness and others' affirmation of their ability to perform the role.

Responses from advisors and department members to Science Squad participation more indirectly communicated values and norms about the relative status of teaching, research, and outreach. Interviewees reported resisting some dismissive attitudes that they encountered. Some people "wondered why I was involved with that program as opposed to sticking to the normal path—but that rarely stops me from doing these sorts of things anyway," said one. Rather, members took pride and pleasure in their work and felt they were contributing something meaningful. These attitudes signal their *investment* in teaching by "commit[ting] something of personal value such as time, alternative career choices, self-esteem, social status, or reputation" *(Weidman et al., 2001, p. 17)*. By contrasting these experiences with research and articulating their own beliefs about outreach and teaching, Science Squad members clarified their personal values and came to see themselves as scientists who worked in teaching. Thus even negative responses to their choices were helpful in clarifying their investment in this career path.

In sum, although members held high pre-existing interest and investment in science careers involving education and communication, Science Squad participation added value by providing substantial experiences of all three elements of socialization.

Differential Outcomes of Socialization as Scientist-Educators

The distinct traits of the strategists and seekers reflect differences in graduate students' socialization needs. With their career goals clearly in mind, strategists did not see adequate opportunity to develop desired teaching and communication skills within their degree program *(Thiry et al., 2007)*. They proactively sought out the Science Squad as a way to meet these needs, timing their participation to coordinate with their research agenda and limiting it to derive maximum return on investment. For these students who envisioned a future scientific identity that combined research, teaching, and outreach, Science Squad involvement provided missing knowledge and skills, and confirmed their prior investment in that identity.

Seekers, however, were actively questioning the professional identities presented by their graduate program. Rejecting certain aspects of the proffered life or work, they too were proactive in seeking alternative uses of their skills and interests. For them, the

greatest impact of Science Squad participation was affective, as they disinvested in a previous career identity and reinvested in a different kind of science career. This was at minimum reassuring, and often decisive. Whether or not they ultimately pursued a career resembling their Science Squad experience, members valued the opportunity to test their aptitude and interest firsthand. Interacting with Biological Sciences Initiative staff was often important for seekers, who saw them as role models of possible future careers in outreach.

Seekers and strategists may also differ in how they saw the need to conform *(Antony, 2003)*. Seekers generally resisted the hierarchy of values about teaching and research that they understood from their departments—like Antony's group who, believing they had to adopt prevailing values, were more likely to reject the faculty profession altogether. In contrast, strategists may have been more able to adopt certain values and ignore others, and thus to enter the profession without feeling they had been compromised.

Socialization into the Practices of Outreach and Engagement

These findings highlight how participation in an outreach program can enhance graduate students' growth as educators. What about their development as professionals in outreach and engagement? On this point our data are more sparse but suggest generally positive influences. First, four Science Squad members became outreach professionals. These individuals share roles and personal traits with "boundary spanners," people who broker university-community engagement through their ability to build and hold the trust of community members *(Weerts & Sandmann, 2008)*. Boundary spanners are usually academic staff rather than faculty and commonly have backgrounds as advocates and practitioners; several of the Biological Sciences Initiative staff fit this categorization. For some members, Science Squad provided important exposure to non-faculty outreach careers in academic settings.

Moreover, among Science Squad members who became faculty, several described outreach work as a significant part of their job: "I feel like I can do the research that I've come to enjoy, and do the teaching that I really enjoy, and yet also participate in promoting science to younger people." In several respects, Science Squad members resemble faculty who are highly involved in service, engagement, or engaged scholarship: Many are women and people of color *(Antonio, Astin, & Cress, 2000; Colbeck & Michael, 2006; Vogelgesang, Denson, & Jayakumar, 2010)* who see their professional

identity as interdisciplinary, synthetic, or integrative *(Colbeck & Weaver, 2008)*. This likely reflects both members' predispositions and their enhanced capabilities, interests, and values following Science Squad participation.

The contributions of extra-departmental campus activities may be omitted from visions of engaged graduate education that center on formal degree requirements *(e.g., O'Meara, 2008)*. Yet participation in non-departmental outreach is elective and individualized, which imbues it with personal meaning. These findings support an inclusive view of the sources of professional socialization both on and off campus, in which campus outreach programs may be allies in bolstering graduate education. Indeed, the socialization offered by extra-departmental programs may be especially crucial for those pursuing career paths not fully sanctioned by their departments.

Implications for the Practice and Spread of Science Education Engagement in Universities

The Introduction described three strands in higher education that do not routinely cross paths: scientist involvement with education, graduate education of scientists, and community engagement of universities. Yet in the Science Squad program, these strands come together synergistically. It has been reported that STEM disciplines participate less often in engagement activities *(Vogelgesang et al., 2010)*, but surveys of faculty may not capture the work of non-faculty specialists who, like the Biological Sciences Initiative's permanent staff, are crucial "boundary spanners" *(Weerts & Sandmann, 2008)*. Our data do expose some messages about the value of engagement that circulate in STEM departments and that may assist or hinder the uptake of community engagement concepts in STEM disciplines.

One way to overcome these barriers is to identify synergies between the goals of scholarly engagement and the motivations of existing science outreach programs such as "broader impact" of research grants. Like other authors *(Buchanan, Baldwin, & Rudisill, 2002; deKoven & Trumbull, 2002)*, we find this work to be scholarly in many respects. Science Squad members applied their disciplinary expertise to making knowledge relevant and meaningful to non-expert audiences. They took a scholarly approach to teaching through observation, practice, reflection, and discussion and could readily articulate how their scientific interests connected to their communication and education roles. Such work should thus be easily integrated into university goals for community engagement. But so far, the language and ideas of "engagement" have not

penetrated far into the community involved in science outreach. Perhaps graduate students themselves offer the bridge, in carrying university expertise to the community in ways that powerfully enhance their own educational experiences and future careers.

Conclusion

This study suggests that an intensive experience as a science outreach educator can provide graduate students with three important elements of socialization into the profession of scientist-educator:

1. specialized knowledge and skills needed to succeed as a scientist-educator;
2. direct involvement with the profession's activities, colleagues, and personal meanings; and
3. personal investment in the role and status of the profession.

The relative importance of these three elements, and how they played into later career choices, differed among students. For some students, outreach participation confirmed their career intentions and provided the knowledge and skills needed to succeed in that path. For others, participation facilitated a change in career direction by providing a low-risk opportunity to explore an alternate career and, sometimes, discover new career options in science.

The evidence from this study highlights how this type of socialization benefits individuals. Collateral effects are also evident within the university. Scientists' involvement with education is amplified both in the present and throughout their careers. Participation also enhances the education of scientists, developing skills and capacities useful in academic or non-academic careers. The Science Squad provides one model by which universities can pursue this type of win/win strategy.

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