Beyond the numbers: understanding how a diversity mentoring program welcomes students into a scientific community

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Citation: Ahern-Dodson, J., C. R. Clark, T. Mourad, and J. A. Reynolds. 2020. Beyond the numbers: understanding how a diversity mentoring program welcomes students into a scientific community. Ecosphere 11(2):e03025. 10.1002/ecs2.3025

Abstract. Programs designed to broaden participation in science are often deemed “successful” based on quantitative evidence such as student participation rates, retention, and persistence. These numbers alone only explain that a program met its goals; they seldom critically explain how, specifically, the program achieved its success. To address this gap, we studied students’ perspectives about and experiences with the Ecological Society of America’s award-winning education and diversity mentoring program, Strategies for Ecology Education, Diversity and Sustainability (SEEDS). The persistence rate in ecology by SEEDS participants is three times greater than the national average, but the numbers alone do not explain the program’s impact. We explored the reasons why this program has been so successful by gathering qualitative data as direct evidence explaining how SEEDS influenced participants’ decisions to study science and pursue science careers, and the resulting integration into a scientific community. We coded open-ended survey responses from SEEDS alumni against a social influence theoretical framework that proposes three dominant processes that predict students’ integration into a scientific community: scientific self-efficacy, scientific identity, and shared values with the scientific community. We not only found emergent evidence for all three processes, but we also gained a deeper understanding of how—in participants’ own words—SEEDS achieves its success. Specifically, SEEDS successfully welcomes students into a science community by (1) providing both breadth and depth of programming that offers flexible, multilayered approaches to developing self-efficacy to fit the needs of diverse students, (2) enabling participants to integrate a science identity into other preexisting identities, and (3) implementing programming that intentionally helps participants to consciously connect their values with those of their communities.

Key words: broadening participation in science; ecology; qualitative research; scientific integration; science, technology, engineering, and mathematics persistence; undergraduates; underrepresented minority.

INTRODUCTION

Scientists often refer to professional societies as their intellectual homes. Annual meetings have all the hallmarks of family reunions: boisterous greetings with people we have not seen in a while, catching up on all the news, and even the occasional squabble. We talk about genealogies and refer to ourselves as the academic grandchil-

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Received 8 July 2019; revised 29 October 2019; accepted 4 November 2019; final version received 25 November 2019.
Corresponding Editor: Debra P. C. Peters.
should not be surprised, then, that this sense of belonging to a community—to an intellectual family—is a strong indicator of persistence within a discipline (Summers and Hrabowski 2006).

The importance of community and a sense of belonging is an emerging theme in the literature on persistence in fields of science, technology, engineering, and mathematics (STEM), for all students but particularly for underrepresented minorities (URMs). Studies have documented how effective diversity programs foster a strong sense of community among participants (Summers and Hrabowski 2006). These findings are particularly important when juxtaposed against other research contending that for over 40 yr, many inclusion programs have not been consistently successful in significantly increasing persistence in STEM by URMs (Haring 1999, Schultz et al. 2011). Many of those programs focus(ed) on providing academic and financial support for students from traditionally underrepresented groups, both of which are essential for students to gain access to higher education (Haring 1999, Lent et al. 2005). However, academic and financial support are not sufficient to promote persistence; students also need to feel accepted into scientific communities that historically have not been very welcoming (Mourad et al. 2018). Once access has been secured, the ultimate effectiveness of diversity programs may hinge on programs’ ability to target the underlying variables that hinder or accelerate students’ decisions to persist in science careers over the longer term (Griffith 2010, Price 2010).

Studies that look at the effectiveness of programs designed to broaden participation in science often look at quantitative outcomes, such as graduation rate and persistence in STEM majors; less has been published about how or why interventions lead to improved persistence in a discipline (Schultz et al. 2011). Qualitative analysis not only can complement quantitative research, but it can also “offer a more nuanced viewpoint” (Gibau 2015:2) and can deepen an understanding for the context of a program (Metcalf 2016). This qualitative analysis allows us to understand the mechanisms by which programs achieve their successes, not simply through anecdotal reporting, but by rigorous and systematic methods that identify patterns of student responses, giving us confidence in the reliability of the results.

Additionally, most evaluations of diversity programs collect data during or immediately after an undergraduate experience, and few studies provide data on programs’ impacts years after graduation. This study addresses both of these gaps in the literature. First, this study asks how a program designed to broaden participation in STEM intentionally and systematically promotes three processes associated with decisions to persist in science: scientific self-efficacy, scientific identity, and shared values with the scientific community. Second, this study focuses on responses from program alumni, looking back at the program’s impact over time. We conducted this study by analyzing qualitative data from an evaluation of a highly successful education and diversity program, the Ecological Society of America’s Strategies for Ecology Education, Diversity and Sustainability (SEEDS). These data allow us, first, to examine whether or not the three processes named above are strong enough to emerge from open-ended questions without explicit prompting. Second, we unpack the three processes against a social influence theoretical framework to describe the ways in which SEEDS has successfully broadened participation in the field of ecology.

**THEORETICAL FRAMEWORK**

Kelman (2006) proposed three processes that influence personal integration into a community: rule orientation, role orientation, and value orientation. The context for Kelman’s research included socialization into national or ethnic identities, with particular focus on the “...depth and durability of change produced by social influence” (2006:3). More recently, Estrada et al. (2011) narrowed this focus to socialization into science communities, particularly by URMs. The three processes are described below, first with Kelman’s original 2006 definitions, second as studied by Estrada et al. (2011), and finally, as contextualized for this study.

Kelman’s first social influence process was a “rule orientation,” or compliance with societal rules (2006:14); Estrada et al. (2011) operationalized this as scientific self-efficacy, meaning in the context of an academic setting that students have...
the literacy and skills to obtain an academic major in science. We further unpack this construct by considering factors that Bandura (1997:79 and ff.) claims contribute to the development of self-efficacy. The most obvious, perhaps, is mastery experiences. Usher and Pajares (2008) reviewed literature about, and made further suggestions for, the formation of self-efficacy in academic settings, finding that mastery experience is consistently the source most likely to predict academic self-efficacy, and vicarious experience the least likely. Although mastery had the most consistently predictive findings, Usher and Pajares acknowledge that this may be the result of methodological limitations.

Second, Kelman suggested that “role orientation” was an important process “…when an individual accepts influence from another person or a group in order to establish or maintain a satisfying self-defining relationship to the other” (2006:3–4). Estrada named this process scientific identity, adding that it allows individuals to engage with a social system, which then results in a social system defining an aspect of the self, and the person feeling a sense of belonging (2011). Scientific identity can manifest as self-identification, the recognition of oneself as a scientist, for example, and group identification, the recognition that one belongs to a group. Additionally, evidence suggests that overlapping social and professional networks, particularly in the form of learning communities, contribute to a stronger sense of group identification (Stolle-McAllister et al. 2011, Hall et al. 2014, Kudish et al. 2016, Maton et al. 2016).

Finally, Kelman’s third process was “value orientation,” or the actual internalization of values held by society, which Estrada et al. called scientific value endorsement and defined as when individuals accept influence to maintain internal and shared values and beliefs. We propose the term shared values with the scientific community for this third process to emphasize the connection of people who have shared goals and belief systems. In the context of the SEEDS community, we include two further modifiers: a commitment to useful and important work and a commitment to diversity. Throughout this paper, we use these terms—scientific self-efficacy, scientific identity, and shared values with the scientific community—to understand how a diversity program has helped students develop a sense of belonging within a scientific community, a process we are calling scientific integration.

Estrada et al. (2011) empirically tested Kelman’s model with data from 719 science students from traditionally underrepresented groups (42% African American, 43% Hispanic/Latino/Latina) recruited from 50 universities across the United States. Using a structural equation model framework, they showed that each process was significantly correlated with scientific integration, although scientific self-efficacy was a poorer predictor of persistence than science identity and shared values with the scientific community. In other words, students were more likely to persist if they felt deeply integrated into the science community and if they were motivated by shared values; students were less likely to persist simply because they felt competent in doing the work associated with being a scientist. Juxtaposing these two findings leads to the interesting inference that although mastery is the best predictor of self-efficacy, self-efficacy may be a poorer predictor of persistence.

**Description of SEEDS**

Strategies for Ecology Education, Diversity and Sustainability is the award-winning, flagship education and diversity mentoring program of the Ecological Society of America (ESA), a professional society representing 8000 professional ecologists in the United States and around the world. Strategies for Ecology Education, Diversity and Sustainability is designed both to recruit undergraduates—particularly those from groups historically underrepresented in science—into the field of ecology and to diversify the field of ecology careers. This program not only boasts 85% persistence rates in ecology and ecology-related majors by URMs (compared to a national average of 24% persistence in STEM, Gibbs et al. 2016), but also retains 71% of its working alumni in ecology or ecology-related careers (Mourad et al. 2018). SEEDS has been recognized for its successes with two major awards: the Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring (PAESMEM) in 2006 and the American Institute of Biological Sciences Diversity Leadership Award in 2008.
Strategies for Ecology Education, Diversity and Sustainability’s mission to diversify and advance the ecology profession, especially for URMs, is accomplished through five primary programmatic components (see Mourad et al. 2018 for detailed descriptions of program components). Participation and mentoring at ESA annual meetings: SEEDS participants attend the six-day annual meeting in which they present their undergraduate research, attend scientific sessions, participate in a career and graduate school fair, and build community through social gatherings. Mentorship is critical for this SEEDS component; participants are paired with either a faculty member or an advanced graduate student who guides them through the annual meeting and engages them in dialogue about their research and career interests. Field trips: SEEDS students have the opportunity to attend field trips ranging from half-day outings to 3-d experiences in ecologically significant areas such as Long-Term Ecological Research field sites. When on site, students tour the facilities, talk with scientists conducting ecological research, and participate in a data collection and analysis exercise. There is formal time for professional development and—equally important—informal time for community building. SEEDS chapters on college campuses: There are approximately 100 SEEDS campus chapters that are co-organized by students and faculty mentors. Chapters are completely autonomous, and they organize programs designed to encourage participation in the field of ecology through activities such as local field trips, career talks, and campus BioBlitz events. Undergraduate research fellowships: This prestigious, yearlong fellowship supports a summer’s worth of ecological research at a field station. Fellowship recipients also participate in leadership meetings before and after their research experience, as well as presenting their research at the ESA annual meeting. Leadership meetings: These annual meetings are designed to encourage SEEDS fellows and selected campus chapter leaders to make connections between science and society, develop communication skills, consider policy implications of ecological research, and/or develop a community outreach activity. In addition to talks, workshops, and tours, there are career panel discussions and opportunities for networking. Common features of these five SEEDS components are “high-impact practices” (Schraw 1998, Trujillo and Tanner 2014) such as hands-on experiential learning, reflection, debriefing, focus on the importance of diversity in science and society, and consideration of participants’ potential roles in the field. SEEDS’s multilayered approach to engagement allows students to participate in one or more programs as their needs and interests dictate.

METHODS

In 2013, with funding from the National Science Foundation, ESA hired a private consulting firm (FERA, Formative Evaluation Research Associates) to conduct an independent evaluation of SEEDS (Mourad et al. 2018). A survey was developed with input from the SEEDS advisory board and staff, and included the following: (1) outcome measures that studied impacts on students’ education, career choices, community involvement, and personal growth; and (2) formative measures that explored the perceived value of SEEDS components and areas for enhancement and additional support. The anonymous, online survey was administered to 517 SEEDS active students and alumni who participated in at least one of the SEEDS core components (field trips, leadership meetings, travel awards to the ESA annual meeting, and undergraduate research fellowships) between 2002 and 2013. A total of 222 SEEDS participants completed the survey (alumni = 161, active students = 61), a 43% response rate.

This study focuses exclusively on responses from SEEDS alumni to allow us to understand not only SEEDS’s impact on participants’ undergraduate education, but also on career choices and persistence in a science career beyond college. Alumni reported that on average, 7 yr had elapsed from the time that they began their participation with SEEDS (n = 156; range: 1–13 yr). We analyzed answers to two open-ended questions from the survey: (1) “Are there other ways that SEEDS had an impact on you?” and (2) “Do you have any final thoughts about SEEDS?”

Four closed-ended questions, placed prior to these questions, asked for Likert-scaled responses about SEEDS impact on career, community involvement, education, and personal growth; we then asked open-ended questions about
impacts other than those. However, we found that respondents frequently took this opportunity to expand on the reasons for the impact in the four named areas. Further, many of the comments in the “final thoughts” question also contained content about the impacts of SEEDS. Therefore, although we analyzed the answers to the questions separately, in this study we have aggregated all responses about the impacts of SEEDS.

We used NVivo11 qualitative research software to organize and analyze survey responses, moving the project into NVivo12 when it became available in 2018 (QSR, Burlington, Massachusetts, USA). Two members of the research team (J. Ahern-Dodson and C. R. Clark) collaboratively developed an initial list of themes to which the data would be coded, and then independently coded responses to those themes. Both coders added themes to the list as they thought relevant to the research question. They then combined their codes, worked together to identify points of consistency and inconsistency, redefined code definitions as needed, and finalized a second draft of the code list. Some of the initial codes were deductive (such as coding to processes borrowed from the Kelman 2006 model, with input from Estrada et al. 2011 and Bandura 1997), and others emerged from the data inductively, such as “commitment to diversity.” The overall code structure was reorganized after consulting with the entire writing team, particularly those who are most knowledgeable about the program history and current status (T. Mourad and J. Reynolds). In some cases, we cross-tabulated the quantitative and qualitative data using matrix queries in NVivo.

In our qualitative coding, a “comment” is defined as the full response to one of the two open-ended questions in our study. We coded 71 comments from alumni respondents providing open-ended comments about the impact of SEEDS, and 92 comments from alumni respondents to the “final thoughts” question, resulting in 163 total comments being coded for this study. Any single comment may have multiple “references” (i.e., area of contiguous text) within it, and each reference could be coded to a number of different relevant codes. The result of this double counting is that at times, the number of references will add up to more than the total number of comments. In other instances, the number of references in subcategories will exceed the total for the parent category.

IRB approval for this research was obtained through Duke University (Protocol # B0860, Diverse People for a Diverse Science).

**Results**

We found evidence that SEEDS influences students’ decision to persist in ecology and science through all three processes described in the social influence theoretical framework: scientific self-efficacy, scientific identity, and shared values with the scientific community (Fig. 1). Although some themes are more common than others in our data, all three processes that determine student integration into a scientific community emerged strongly.

**Scientific self-efficacy**

We coded 169 references to scientific self-efficacy, divided into four subcategories: mastery experiences, emotional/psychological states, social persuasion, and vicarious experience (Fig. 1).

We coded 48 statements about mastery experiences (related to how a person’s previous successful achievement of the same or a similar task impacts their belief in their ability to complete a new task). Comments in this category connected an experience with SEEDS with their growing confidence:

...because of my experiences in SEEDS and in particular the Leadership meetings, I have the confidence to defend my ideas when others challenge me or do not see the relevance of thinking on such large scales. [Respondent ID: 1568]

Statements about emotional/psychological states were identified in 37 references, including the following:

I met my life mentor at the ESA meetings. People who have supported my career decisions, mentors who have guided me at times of confusion, frustration, and have all experienced the same. SEEDS grew the leader in me—gave me courage to do the right thing for communities, people and ultimately MY people. [Respondent ID: 5094]

Statements about social persuasion (i.e., the support and encouragement received from one’s community) were coded in 49 references, such as the following:
Through SEEDS I began to visualize a different career for myself, one that involves media and expressing myself more creatively than doing empirical research. I can now see myself as a communicator of science or some sort of bridge between researchers and the public. SEEDS encouraged me to write and I now have a blog that I want to develop into the webpage for a nonprofit. I made a movie for the first time during a SEEDS Leadership meeting. [Respondent ID: 8693]

SEEDS believed in me when I didn’t believe in myself. My involvement gave me the confidence to hold my head up in the world and be proud of my cultural identity. Prior to my involvement in SEEDS, I didn't believe I was capable or success. The SEEDS program gave me a support network and a place I could feel safe pursuing my educational dreams. The most important thing SEEDS gave me was the belief I deserved to dream. [Respondent ID: 0191]

Finally, we coded 35 references to vicarious experience (i.e., feeling able to complete a task because others with whom one identifies have had success at the task) illustrated by comments like the following:

SEEDS was a springboard that allow me to reach and sit side-by-side with superstars or highly professional people and other peers like me. Mostly I am thankful to keep in touch with other SEEDS members that constantly showed me the several basics to be competent, effective and happy with who I am and what I want to be. [Respondent ID: 6416]

Scientific identity.—We coded 194 references to the scientific identity code of the social influence model, divided into three sub-components:
self-identification, group identification, and overlapping social and professional networks (Fig. 1).

We coded 100 references to the code self-identification. Some comments referred to participants' identity as ecologists:

Once I opened the door into the SEEDS’ house, I found myself like Alice in Alice in Wonderland. Every character I meet, every situation I encounter, every solution that is given, I value all my experiences because through SEEDS I have formed myself into the professional that I am now in the field of Ecology. [Respondent ID: 1218]

Other statements referred more broadly to participants' identity development:

As a Native American woman – I was told, by my own parents, that I could never be a doctor, successful, or a leader. I’m not a doctor (yet) but I am a courageous leader, a successful woman, and most of all I understand all the affects my work has on the earth, people & resources – I am now a protector too. [Respondent ID: 5094]

Sixty-four references were coded to the code group identification, with comments such as the following:

SEEDS connected me with other students of color that had similar interests as me and gave me the confidence that I too could pursue a degree in this field. [Respondent ID: 5940]

…the experience has been phenomenal and influential primarily because of the active network of alumni, diverse professionals, engagement opportunities…and all around camaraderie established by the program for its students. [Respondent ID: 5252]

We coded 30 unique references to the code overlapping personal and professional networks. Examples include the following:

SEEDS changed my life! It is honestly one of the best things that has happened to me personally and professionally. It provided a professional network that feels more like a family [Respondent ID: 7449]

and

Prior to my involvement in SEEDS, I didn’t believe I was capable of success. The SEEDS program gave me a support network and a place I could feel safe pursuing my educational dreams. [Respondent ID: 0191]

1. Shared values with the scientific community.—

We coded 199 references to shared values with the scientific community, divided into three sub-components: commitment to useful and important work, commitment to diversity, and shared goals.

We found 126 references from SEEDS respondents who believed that their scientific community was making a commitment to useful and important work. Representative statements include the following:

SEEDS is making a substantial difference in advancing the environmental field by developing leaders that know how to utilize the strength of diversity to advance ecology and our understanding of the environment. [Respondent ID: 5018]

Statements about commitment to diversity were coded 62 times, with representative comments such as the following:

Awareness of environmental justice as well as racial and class discrimination in ecology made me feel like I wasn’t alone as a poor kid trying to get through school and compete. [Respondent ID: 7286]

Examples of explicit acknowledgements of shared goals (11 references coded) include statements such as the following:

[SEEDS] introduced me to all kinds of people with different personalities, but with a common goal to save our ecosystem. [Respondent ID: 5425]

DISCUSSION

Previous research demonstrated that 80% of SEEDS alumni survey respondents had completed at least one degree in an ecology-related field. For URM alumni, 85% earned a degree in an ecology-related field. Overall, 71% of working SEEDS alumni respondents have careers in ecology (Mourad et al. 2018). Although impressive, these numbers alone cannot explain how the Ecological Society of America’s program achieved this success. Through qualitative analysis, we found emergent evidence that SEEDS influences participants’ decisions to persist in science, at least in part, through promoting scientific self-efficacy, scientific identity, and shared values with the scientific community. It would be impossible to attribute these outcomes directly to specific SEEDS components because of the limitations of
our data, but also because these processes develop over time and are influenced by other factors in participants’ lives. Nonetheless, survey responses strongly show that participants connect their integration into the scientific community with their participation in SEEDS. Based on these results and our knowledge of SEEDS programs and philosophy, we propose the following three explanations for how SEEDS has promoted these processes.

First, we found that SEEDS helps participants develop self-efficacy by providing both breadth and depth of programming to fit the needs of diverse students. For some, this is achieved through mastery experiences such as engaging in authentic ecological research during a field trip (“[The] SEEDS fieldtrip was a turning point in my life… afterwards I was completely confident that I wanted to dedicate my professional career to the field of conservation and sustainable management of natural resources…”; Respondent ID: 1877). Another participant may build that sense of confidence through social persuasion, that is, sustained encouragement from a mentor at (“I met my life mentor at the ESA meetings”; Respondent ID: 5094). People come to “know” information by scaffolding new ideas onto previous experiences (Atwater 1996). SEEDS not only provides scaffolding, but also recognizes that each student is starting from a different place and, therefore, they each need different types of support in order to feel like they are part of the scientific community. Each SEEDS participant has a unique experience depending upon their education, beliefs, past opportunities, and future goals. The SEEDS program allows for—and embraces—this diversity of backgrounds and offers participants flexible, multilayered approaches for engagement, and this flexibility is a core component to culturally responsive practice (Hollins 2015). Participants can engage at different points in their undergraduate career when they have different needs. For example, some participants might get involved in their first few semesters of college as they are trying to find their academic niche, whereas others might first engage with SEEDS when they are looking for research experiences near the end of their college years. This allows SEEDS program components to complement and reinforce each other. As seasoned experts know, the path to success is rarely linear; yet novices in any field may feel discouraged by forks in the road, barriers, and setbacks. SEEDS is successful both because its design welcomes students—wherever they might be—as they discover ecology career pathways along one of multiple pathways and because SEEDS helps participants navigate hurdles toward persistence.

Second, SEEDS helps participants develop their sense of identity as an ecologist by acknowledging—and valuing—that they have multiple identities (Treisman 1992, Merolla and Serpe 2013, Lane 2016). Participants are not only students; they are also members of families, tribes, races and ethnicities, nationalities, sociocultural communities, religions, universities, teams, and clubs. As a result, they are developing their identities as ecologists while simultaneously trying to merge that scientific identity with their myriad other identities. This is evident by the fact that respondents name their multiple identities and explain how SEEDS helped integrate disparate identities. For example, SEEDS gave a single mother and “older than average student,” who did not believe she “ha[d] the right to dream” or was “capable of success,” the “confidence to hold [her] head up in the world and be proud of [her] cultural identity” [Respondent ID: 0191]. SEEDS helped another student feel less isolated “as a poor kid trying to get through school and compete” [Respondent ID 7286] and fostered a Native American woman’s belief that she is “a courageous leader” and “a protector” who “understand[s] all the affects [her] work has on the earth, people & resources,” despite her family telling her she “could never be a doctor, successful, or a leader” [Respondent ID: 5094]. By supporting the whole person and acknowledging competing narratives about her capabilities, SEEDS, she commented, “gave me courage to do the right thing for communities, people, and ultimately MY people” [Respondent ID: 5094]. Whereas some programs may avoid engaging with the non-academic aspects of their participants, SEEDS embraces students as complex human beings. It provides opportunities for explicit conversations to help participants integrate their multiple identities without privileging
a science identity at the expense of other identities.

Third, through intentional programming such as critical self-reflection (Schon 1983, Kolb 1984, Ash and Clayton 2009), SEEDS helps students consciously connect their values with those of their community. SEEDS is built on an ethos of shared values, a commitment to diversity, and useful and important work. Instead of avoiding discussions of values, this is a core feature of the programming. Specifically, SEEDS creates opportunities for explicit discussions of the value of diverse perspectives and the social justice issues related to ecology. In addition to discussions, participants are encouraged—both orally and in writing—to reflect not just on career aspirations, but also on how they see their career connecting their values to the environment. As one respondent writes, SEEDS is “developing leaders that know how to utilize the strength of diversity to advance ecology and our understanding of the environment” [Respondent ID: 5018]. By helping students feel deeply connected to and supported by an academic community, SEEDS promotes a sense of agency for its participants.

This research has demonstrated the importance of qualitative analysis in understanding the success of education and diversity programs and has expanded our understanding of why SEEDS, in particular, is so successful. We do acknowledge, however, that there are limitations to our results. It is not possible from our data to link student outcomes either with specific SEEDS components or with how much time participants were involved with SEEDS. We assume that some participants benefit more from short but intense experiential, immersive experiences (such as a field trip) than, for example, a yearlong leadership program with less in-person contact hours. For others, however, the opposite is likely to be true; a less intense but more sustained experience may be more impactful (e.g., a mentor/mentee relationship sustained over a number of years, even if in-person contact is infrequent). Additional research would need to be done to understand the characteristics of participants and why some SEEDS activities are more impactful for them than others.

Additionally, since the process of science integration develops over time, our data cannot pinpoint the activity that was the tipping point for various students. Nonetheless, our experience with SEEDS students over the years suggests that the first interaction they have with our programs is the deepest. We hypothesize that this is the case because our students regularly report (through regular, anonymous, formative evaluations of all SEEDS components) that they had never previously had the opportunity to ask what it meant to be a minority scientist before their first SEEDS event, they had never imagined they could really be part of the scientific community or that there were others who felt like they did, and they never fully believed their ideas were truly valued. These initial insights—that they do belong and that they are valued—can be the most powerful during the first encounter. The type of validation students experience can be very intense and, therefore, life-changing even from just one exposure. For students who participate in multiple SEEDS components, they gain the reinforcement of these ideas and are nurtured for leadership roles within and beyond SEEDS. Future research could investigate the synergistic effect of participation in more than one SEEDS component.

Even with these limitations, our results are consistent with those of Estrada et al. (2011), although we reached a similar conclusion using a completely different methodological approach. Additionally, our study focused on alumni responses—some of whom graduated out of SEEDS more than a decade ago—thus demonstrating that these outcomes are robust and persistent over time. We believe that SEEDS can serve as a model for others interested in designing successful diversity programs. In particular, this work highlights the importance of intentional, flexible, and multilayered programming designed to promote self-efficacy, scientific identity, and shared values with the scientific community as critical processes that influence students’ integration into scientific communities and feel a sense of belonging within an intellectual family.

Acknowledgments

We graciously acknowledge the contributions of Amy McNulty, Desiree Liwosz, and Karin Tice of Formative Evaluation Research Associates (FERA) for working with ESA SEEDS manager, Fred Abbott, to
design, administer, and compile the survey findings. We are also thankful for all the input and guidance of the 2013 SEEDS advisory board: Melissa Armstrong, Mark Brunson, Marnie Carroll, Quintaniay Holifeld, Chris McLaughlin, Ricardo Rozzi, Jeramie Strickland, and Zakiya Leggett. Thanks also to the National Science Foundation for its ongoing support and funding (No. DEB-1261389, Diverse People for a Diverse Science). The authors are listed in alphabetical order to reflect their equal contribution to this study.

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