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Undergraduates' Perceived Gains and Ideas About Teaching and Learning Science From Participating in Science Education Outreach Programs

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Abstract

This study examined what undergraduate students gain and the ideas about science teaching and learning they develop from participating in K-12 science education outreach programs. Eleven undergraduates from seven outreach programs were interviewed individually about their experiences with outreach and what they learned about science teaching and learning. Emergent themes were identified from a content analysis of transcript data. Undergraduates reported career, academic, and personal gains. Undergraduates also recognized that understanding students, the nature of science and scientific practices, active learning, and student interest are important for science teaching and learning. These results were compared across outreach programs to determine how the type of program may affect undergraduate outcomes. This analysis indicated that although there were commonalities in undergraduates' experiences independent of the type of program, program elements that may affect outcomes included corresponding coursework or additional duties and the degree of focus on scientific practices.

Introduction

Increasingly, university science departments are developing partnerships with local K-12 schools to advance mutual goals related to improving science education (*James et al., 2006; Tanner, Chatman, & Allen, 2003; Williams, 2002*). University and K-12 partnerships not only have the potential to improve K-12 education, but can improve university education as well. According to Tanner et al. *(2003)*, these partnerships have the potential to improve teaching practices at all levels and increase the coherency of science education across the K-12-to-university continuum. The term *partnership* underscores the bidirectional, reciprocal nature of these programs that are formed on common goals and provide learning opportunities for both sides (*James et al., 2006; Laursen, Thiry, & Liston, 2012; Williams, 2002*).

University partnerships with K-12 schools often take the form of outreach programs. University science outreach programs vary

greatly in duration, content, and format. Outreach programs may, for example, include short- or long-duration after-school programs, classroom interventions, research experiences for teachers, or university excursions for children (*Laursen, Liston, Thiry, & Graf, 2007; Moskal & Skokan, 2011; Williams, 2002*). Studies have documented positive impacts of outreach on K-12 students and teachers such as increased interest in science for students and improved content knowledge for teachers (*Laursen et al., 2007; Williams, 2002*). More research is needed not only on the impacts of outreach on K-12 students, but on the learning opportunities for participants on the other side of the partnership—the university participants providing the outreach. This study investigated what undergraduate students gained from participating in K-12 science education outreach programs, the ideas about science teaching and learning they developed, and how the type of outreach program affected these outcomes.

Literature Review

University Outreach Participants

Much of the research on university outreach participants has focused on graduate students, highlighting a need for more research on undergraduate participants. However, the literature on graduate students is useful to establish a baseline understanding of how participating in outreach impacts university student participants. The prevalence of research on graduate students (in comparison to undergraduates) may be due in part to the former NSF Graduate Teaching Fellows in K-12 Education (GK-12) Program that partnered graduate students in science, technology, engineering, and mathematics (STEM) fields with K-12 classrooms and teachers (*Ufnar, Kuner, & Shepherd, 2012*). Thus, several studies documented the impacts of participation in GK-12 funded outreach programs on the graduate student fellows. Other studies have examined the impacts on graduate students who participate in outreach programs not affiliated with GK-12. The findings of these latter studies confirm those of the GK-12 studies.

Findings indicate that science education outreach had several positive impacts on graduate student participants. For example, participating in outreach had positive impacts on graduate students' career-related skills such as communication, teamwork, and collaboration (*deKoven & Trumbull, 2002; Laursen et al., 2007; Page, Wilhelm, & Regens, 2011; Stamp & O'Brien, 2005*). In addition to career

skills, many graduate students also gained a better understanding of career options and clarified their career interests, especially regarding careers in education (*Laursen et al., 2007; Laursen et al., 2012; Page et al., 2011*).

Across studies, graduate students experienced gains in science content knowledge and improved their science teaching skills (*Laursen et al., 2007; Stamp & O'Brien, 2005; Thompson, Collins, Metzgar, Joeston, & Shepherd, 2002*). Laursen et al. (*2007*) described several gains in graduate student teaching skills, such as quickly adapting teaching to different audiences, managing classrooms, and developing individual teaching styles. Moreover, graduate students reported gaining a greater awareness of issues such as culture and learning, diversity and equity, the limited amount of time and resources allocated to science instruction, and the importance of university–K-12 outreach (*Laursen et al., 2007; Moskal et al., 2007; Page et al., 2011*).

Although the identified benefits of participating in science education outreach are extensive, studies also document negative impacts and obstacles to graduate student participation. Graduate students experienced various professional risks such as loss of standing in their research groups, setbacks in their own research, and lack of support from advisors (*Laursen et al., 2007; Laursen et al., 2012; Thompson et al., 2002*). The amount of time required by outreach and the difficulty of scheduling outreach activities around their research were considerable barriers to participation (*deKoven & Trumbull, 2002*).

However, these challenges are specific to the academic demands of graduate students. The benefits and risks of participating in science education outreach may differ for undergraduates. For example, undergraduates do not have the research demands that graduate students have. Undergraduates who participate in science education outreach may face different obstacles and reap different benefits. Consequently, examining the impacts of participating in outreach on undergraduate participants is important. However, research about the impacts of outreach on undergraduate participants specifically is lacking (*Rao, Shamah, & Collay, 2007*).

From the sparse literature on undergraduates, impacts on science content knowledge and career skills have been identified. Rao et al. *(2007)* found that undergraduates from three outreach programs learned to integrate scientific information across disciplines, increased their understanding of science concepts, and increased their confidence in sharing scientific knowledge. Undergraduates

also developed transferable professional skills such as communication, leadership, teamwork, and organization (*Grant, Liu, & Gardella, 2015; Gutstein, Smith, & Manahan, 2006; Rao et al., 2007*). Increased exposure and access to faculty and university resources and the opportunities to work with children and undergraduate students from different science disciplines were also cited as positive impacts (*Rao et al., 2007*).

Most of these studies on science education outreach have been evaluations of specific programs rather than systematic studies across multiple programs. However, outreach programs vary, and different types of outreach programs may yield different effects. Possible outcomes of these differences have remained largely unexplored. Determining what elements result in positive and negative outcomes is important for developing programs that maximize benefits and minimize risks for all groups involved.

Experiential Learning and Service-Learning

As shown with graduate students, K-12 science outreach can result in meaningful learning outside the university. This makes sense in light of experiential learning theory and research on service-learning. Experiential learning theory considers the central role of experience in learning (*Kolb, 1984*). From an experiential perspective, learning is viewed as a continuous process in which learners build knowledge, understanding, and skills from direct experiences (*Kolb, 1984; Wissehr, 2014*). Learners participate in authentic situations and actively build understanding by thinking about what they have experienced. What they learn is relevant and useful to their future experiences (*Carver, 1996*).

Science outreach programs can provide undergraduates with the authentic experience of working and interacting with K-12 students. As undergraduates participate in the outreach experience, they can build knowledge, understanding, and skills that are personal and relevant to their futures. More research is needed to better understand outreach as an experiential learning opportunity for science undergraduates. Through such improved understanding, outreach program leaders will be able to maximize the learning opportunities for undergraduates and to recruit more undergraduates into outreach. Undergraduates who are made aware of the learning potential of outreach may be more interested in participating.

Science outreach and service-learning offer similar participation experiences. Service-learning in higher education typically

refers to courses that have a specific service component (*Bringle & Hatcher, 1996*). The outreach programs included in the present study were largely extracurricular service activities, although some did offer course credit or had associated coursework. However, the literature on service-learning, particularly in teacher education, is useful in informing this study.

Increasingly, teacher education programs are including service-learning courses to provide preservice teachers with alternative field experiences, particularly experiences of working with diverse students (*Brannon, 2013; Cone, 2012; Vavasseur, Hebert, & Naquin, 2013; Wallace, 2013*). Service-learning provides meaningful opportunities for preservice teachers to interact with K-12 students outside typical classroom situations. Several studies have shown that by participating in service-learning, preservice teachers can develop their knowledge of teaching and learning. For example, Wallace (*2013*) investigated the outcomes of including service-learning and action research in a course for preservice science teachers and found that the preservice teachers increased their knowledge about children as diverse learners and the importance of children's prior knowledge. Similarly, Harlow (*2012*) found that preservice elementary teachers developed their understanding of children's science ideas by facilitating family science night activities.

As with preservice teachers participating in service-learning, when undergraduates interact with K-12 students and teachers through outreach, they are likely formulating ideas about how students learn science and how to best teach science. However, the ideas that undergraduates develop about science teaching and learning from participating in outreach have not been studied.

To address the gaps in the literature, three research questions guided this project: (1) What do undergraduates report gaining from participating in science education outreach programs? (2) What ideas about science teaching and learning do undergraduates develop from participating in such programs? (3) How does the type of outreach program affect undergraduate outcomes?

Study Design

Data were collected from open-ended interviews of undergraduate science students involved in science education outreach. This approach was taken because the goal of the study was to understand the undergraduates' own perspectives on what they gained from outreach. According to Brenner (*2006*), qualitative interviews attempt to "understand informants on their own terms" *(p. 357)* and

the meaning they make out of their experiences. The interviews were designed to elicit the informants' perceptions of their experiences with outreach and what they learned about science teaching and learning from those experiences.

Table 1. ***Summary of Informant Data***

Pseudonym	Outreach program(s)	Year at university	Major	Approx. amount of time participating (Hours)
Lana	Chemistry Outreach	4th (graduating)	Chemistry	>100
Larry	Chemistry Outreach	1st	Microbiology	10-50
Javan	Chemistry Outreach	4th (not graduating)	Chemistry	10-50
Beth	Let's Do Science	4th (graduating)	Biochemistry	>100
Saraf	Let's Do Science	4th (not graduating)	Biochemistry	10-50
Janelle	Physics Is Fun	1st	Biology	<10
Wilson	Physics is Fun	2nd	Pharmacology	<10
Susan	Materials research Outreach	4th (graduating)	Chemistry	<10
Andy	Materials Research Outreach/Family Science Night	4th (not graduating)	Chemistry	10-50 (MRO) 10-50 (FSN)
Amanda	Nature for Kids	3rd	Environmental Studies	>100
Cameron	Marine Research and Education Program	4th (graduating)	Aquatic Biology	>100

Informants

Participants included undergraduates who participated in science outreach programs at a large research-intensive university in California. The university has approximately 40 STEM outreach programs that serve local K-14 students, teachers, and community members. These outreach programs are housed in various science departments across campus and operate largely in isolation from each other. For this study, I contacted only outreach programs that provided opportunities for undergraduates to work with K-12 students. I sent a recruitment e-mail through program electronic mailing lists or by contacting program coordinators. Eleven respondents from seven outreach programs volunteered for this study. Informants represented a variety of majors, outreach pro-

grams, amounts of time involved with outreach, and number of years at the university. Three undergraduates were enrolled in a science and mathematics education minor—a minor for students who are interested in becoming mathematics and science teachers. See Table 1 for a summary of informant data. Human subjects approval was obtained from the university's institutional review board.

Study Context

University and surrounding community. As mentioned, the outreach programs were housed at the research-intensive university where the undergraduates were students. The university is located in an urbanized area with a large Hispanic population. The university is recognized as a Hispanic-Serving Institution by the Hispanic Association of Colleges and Universities. The main school district of the surrounding community is a high-need school district serving a student body that is approximately 35% English language learners and 60% socioeconomically disadvantaged.

Table 2. ***Outreach Program Descriptions***

Outreach program (Pseudonym)	Description of outreach program	Grade levels served
Chemistry Outreach	Stations of chemistry demonstrations in a laboratory on the university campus	5th
Family Science Night (FSN)	Science demonstrations and activities presented in 30-minute sessions at school and community science events	Middle School
Let's Do Science	Inquiry-based modules in elementary school classrooms where elementary students design their own experiments	2nd, 5th
Marine Research and Education Program (MREP)	Hands-on marine science education consisting of tours of a research and educational facility on the university campus with touch tanks and outdoor components	K-12
Materials Research Outreach (MRO)	Materials research activities in middle school classrooms and demonstrations in booths at community science events	Middle School
Nature for Kids (NFK)	Long-duration outdoor environmental education for 5th graders	5th
Physics Is Fun	Physics demonstrations at large school assemblies and booths at school science events	Elementary and Middle School

Chemistry Outreach. In this program, classes of fifth-grade students take a field trip to the local research university, where they rotate through a series of stations with hands-on activities, demonstrations, and discussion of basic chemistry concepts. The undergraduate volunteers work in pairs or small groups to lead the stations. The undergraduates perform demonstrations, lead the activities, and ask and answer questions with small groups of students. The program occurs approximately once a week, serving 25–30 fifth graders each week. More experienced volunteers can become group leaders for a station.

Family Science Night. In this program, undergraduate and graduate student volunteers present 30-minute science activities at various school and community science events (e.g., school science fairs). Volunteers present the activities to small groups of students and families who rotate through the activities.

Let's Do Science. Let's Do Science presents inquiry-based modules that focus on learning the scientific process in local elementary school classrooms. Undergraduate and graduate student volunteers work with small groups of children to help them develop their own experiments. Volunteers participate in approximately five to seven 1-hour sessions per module. Undergraduates are able to receive course credits for participation. Experienced volunteers can become classroom leaders who present to the whole classroom and organize other volunteers.

Marine Research and Education Program. Undergraduates lead tours and hands-on activities at an aquarium facility on the university campus. The program serves all grade levels. Undergraduates begin as unpaid volunteers and work up to paid positions. Unpaid volunteers assist more experienced participants with tours and maintaining aquaria. Paid participants' duties include leading tours, developing content for tours, coordinating tours, and being in charge of specific aquaria.

Materials Research Outreach. In this program, undergraduate volunteers and university faculty travel to local middle school classrooms to lead students in hands-on activities. Middle school students build and test their own toy solar cars and/or build buckyball models. The program also provides interactive booths at community science events where volunteers interact with children and adults.

Nature for Kids. Undergraduates lead environmental science activities for fifth-grade students on field trips to various native habitats. Undergraduates take a corresponding course associated

with a science and mathematics education minor. Undergraduates can return to the program as interns to assist less experienced undergraduates in addition to working with the children. The program serves three fifth-grade classes continuously throughout the school year.

Physics Is Fun. This program brings undergraduate and graduate student volunteers to local schools to perform physics demonstrations for large audiences (e.g., school assemblies). The program also brings interactive booths to local science events where volunteers perform demonstrations for smaller groups. Volunteers are able to receive course credits.

Data Collection

A semistructured interview protocol was developed so that the questions were consistent among informants but flexible enough to adapt for each informant and as each interview progressed. According to Brenner (*2006),* a semistructured protocol involves "asking all informants the same core questions with the freedom to ask follow-up questions that build on the responses received" *(p. 362)*. The protocol was designed using a funnel approach, asking general questions about the outreach program first to establish context and then progressing to more specific questions (*Brenner, 2006; Spradley, 1979; Werner & Schoepfle, 1987*). Potentially sensitive or evaluative questions about the program were asked last, after rapport had been established (*Patton, 1990; Werner & Schoepfle, 1987*). The resulting protocol had three sections: questions about the program, questions about what the informant gained from the program, and questions about the informant's thoughts on the program. Direct prefatory statements were used to introduce each section to the informant (*Patton, 1990*).

Each informant was interviewed once individually, and interviews lasted for 30 to 60 minutes. The interviews took place in a graduate student research office at the university. This location was convenient, private, and quiet. Each interview was audio recorded, and extensive notes were taken throughout the interviews. All audio recordings were transcribed verbatim, but aspects of conversation such as pauses, overlaps, and intonation were deemed unimportant for transcription (*Kvale, 2009; Mishler, 1986; Poland, 2002*).

Data Analysis

A content analysis approach was used to analyze the transcript data. Content analysis focuses on meaning-based patterns

in the data and can be quantitative, qualitative, or both (*Huckin, 2004*). As Mostyn (*1985*) described, the purpose of content analysis is to understand both the manifest and latent meaning of the response within the respondent's frame of reference. According to Huckin (*2004*), in a conceptual content analysis, concepts are selected (either deductively or inductively), coded, and counted. The researcher then tries to identify patterns and reasons for such patterns while keeping the context in mind.

To organize the coding process, a coding scheme was developed with the following types of codes: attribute codes, structural codes, and descriptive codes. According to Saldana *(2009)*, attribute codes relate to specific characteristics such as demographic information. Attribute codes were used to identify basic information about each outreach program and demographic information for each informant. For the outreach programs, transcripts were coded for descriptions of the outreach program, number and level of K-12 students the program served, and incentives given to participants. For each informant, transcripts were also coded for demographic information including major, year at the university, role in the outreach program, enrollment in science and mathematics minor, and time spent participating in the outreach program. The attribute codes were used to provide context for discussing the programs and informants, and for addressing Research Question 3.

Structural codes are content-based words or short phrases that relate to the research questions (*Saldana, 2009*). Structural codes relating to Research Questions 1 and 2 were developed (see Table 3). The structural codes were determined a priori as a way to organize the inductive descriptive codes.

Table 3. ***Research Questions and Descriptions of Structural Codes***

Research Question	Structural code	Description of code
What do undergraduates report gaining from participating in science education outreach programs?	Gains	Instances where informant was directly discussing gains from participating in the programs or indirectly discussing benefits, improvements in skills or understandings
What ideas about science teaching and learning do undergraduates develop from participating in such programs?	Ideas—Teach/Learn	Informants describe or discuss ideas relating to teaching or learning science that they developed from outreach

Descriptive codes are words or short phrases that describe the topic of the text segment (*Saldana, 2009*). As a text segment was assigned a structural code, a descriptive code was also assigned to the segment to describe the topic of the segment. The descriptive codes were determined inductively (data-driven) and refined through successive rounds of coding (*Huckin, 2004; Kvale, 2009*). After the first complete round of coding, the descriptive codes were organized (separated) by structural code and reviewed for similarity and frequency. These first descriptive codes were collapsed into fewer, more discrete codes. Codes that were similar were combined, and infrequently occurring codes were eliminated. The data were recoded using the new set of descriptive codes. Themes were determined from clusters of related descriptive codes and given categorical names (see Tables 4 and 5).

Findings

Research Question 1: What Do Undergraduates Report Gaining From Participating in Science Education Outreach Programs?

The emergent themes related to gains were career gains, academic gains, and personal gains. The number of undergraduates who discussed each code subject and relevant examples are provided in Table 4. Descriptions of the codes describe what informants discussed. Each theme is discussed below.

Table 4. *Themes and Codes Related to Participant Gains*

Themes/Codes	Description	*n*	Example Quotes
Theme 1: Career Gains			
Career—options	Outreach shows options for careers or refines/clarifies/changes ideas about a certain career path; includes careers in education	4	"You can kind of learn whether you do like teaching… and whether that's really the path you want."
Career—development	Networking, resume enhancement, professional growth; describe experience as useful for career advancement	7	"I believe this is what got me into the teacher ed[ucation] program."

Career—skills	Improved career-related skills such as communication and management skills; transferability of skills	7	"I've gained communication skills, presentation skills.
Explain science concepts	Improved abilities to explain science concepts to general audiences	5	"It's been really helpful to learn how to explain science concepts on a really basic level."
Theme 2: Academic Gains			
Faculty	Unique opportunity to work with university faculty	4	"I think it's nice to have that setting with a graduate student and a professor… [it's] a learning experience."
Interest—outreach	Interest in participating in more outreach or other outreach programs	6	"Science outreach is something that I really would like to do, incorporate somehow in my future."
Reflect—own learning	Reflect on own learning or education in relation to outreach experience	5	"Talking a lot about education has given me a lot of new opinions on how fortunate I was to have the background in science that I had growing up."
Understand—education	Increased understanding of education, educational system, discipline of teaching, working with kids	7	"I think my understanding of education has changed more than anything."
Science content knowledge	Increased science content knowledge and understanding of the nature of science	10	"I gained a better concept of angular momentum."
Theme 3: Personal Gains			
Break	Legitimate break from schoolwork; exposure to different age groups and populations	5	"Seriously, it is a nice break in the day, makes me forget about quantum mechanics and other things that don't need to be thought of."
Fun	Experience fun or enjoyable	8	"It was a lot of fun."
Rewarding	Experience rewarding; sense of giving back	8	"It's rewarding knowing you're making a difference and you're actually helping people out."

Note. *n* = Number of participants who discussed code topic.

Career gains. Undergraduates reported gains related to career development. Four undergraduates found that outreach helped them learn about career options and refine their ideas about careers in education. For example, Cameron, who had been accepted into a postgraduate teacher education program, strengthened his interest in becoming a secondary science teacher. He joined the Marine Research and Education Program (MREP) because it "was like bridging the two gaps between research and education," and "as I developed more into leading the tours and stuff, I really, really enjoyed it… that's really what got me into teaching."

Seven undergraduates also found outreach to be useful for networking, resume enhancement, or advancement on a career path. Susan, a senior who was accepted to graduate school, felt that outreach "looks really good if you want to go to grad school, like to put that on your resume." Saraf thought networking was "obviously the most beneficial thing to me, and that's why I joined [outreach]." Janelle felt her experience in outreach would be beneficial for her career path: "Now I feel more comfortable about the role I would play as a doctor, like I guess I could see myself as a doctor as teaching people instead of just like advising people."

Finally, seven undergraduates reported gains in career-related skills such as public speaking, general communication, responsibility, and management. When asked about skills she developed from outreach, Beth reported, "Let's Do Science gives you the opportunity to lead, which I think is a great skill… it gives you organizational skills, people skills, both adult and children… but I would say leadership is the biggest, being a Let's Do Science lead is a lot of responsibility." Performing physics demonstrations in front of large school assemblies in outreach helped another student, Wilson, with public speaking and helped lower his fear of speaking in front of large groups.

Undergraduates also noted the transferability of skills learned in outreach. For example, Javan reported:

> I won't be nervous about taking on a leadership role, I think that's really important, or even if I'm just working with colleagues, the idea of communication and explanation of certain concepts… and seeing different viewpoints… maybe when I'm working with a lab partner or something, maybe… taking a back seat and seeing what they know and then putting together with what I know… what you can take from it is really just dealing with how other people view things, communicating,

> and then be able to collaborate and orchestrate like a team… that's pretty pervasive in any aspect or job.

Javan felt that the leadership, communication, and collaboration skills he learned in outreach would be useful in his undergraduate classes and future jobs.

In addition to general communication skills, five undergraduates found that outreach increased their science communication skills, including improved abilities to explain scientific concepts to general audiences. For example, Lana thought that outreach made her a better science communicator and felt "that's a really valuable skill for a scientist to have, and I don't think many scientists appreciate how important communication can be." When asked about skills he improved, Andy replied:

> Relating the science at all levels… I definitely got better at that, and quickly I realized how hard that was, and how not good, well, my lack of experience in that, I realized that very fast. Probably the first two events I was like, "Wow, I really need to be able to explain this to a little kid and then quickly to an adult."

In the Family Science Night outreach program, Andy gained experience explaining science concepts to children as well as adults. This improved his ability to communicate scientific concepts to different audiences.

Academic gains. Undergraduates also reported gains related to their academic lives. Four undergraduates indicated that outreach allowed unique opportunities to work with university faculty. Amanda described the opportunity she had:

> [The professor who leads the outreach program] has really been opening a lot of doors for me and that's really been awesome, because not a lot of people talk to their professors and really know them and have a relationship with them… I really have that access to those people which is huge in professional and educational growth.

However, not all undergraduates reported opportunities to work directly with the university faculty who run outreach programs. As Wilson described, "There's a person in charge… he's my physics professor but I've never seen him at an event."

Five undergraduates reflected on their own learning and undergraduate experience based on their outreach participation. For example, from her experience teaching fifth graders in Chemistry Outreach, Lana realized:

> If you put in the time and… you have teachers that support you and are willing to work with your learning methods, like really anyone can learn science, it just might take some people longer than others. That's been really helpful, kind of in my approach to work and to school science classes just because if I get stuck like I don't think, "Oh, I'm not smart enough to finish this." I just think, "Well, I haven't thought about this in the right way or I should try and get someone else to explain this to me and maybe it'll click using the words they're using." And not really approaching it with the mindset of like, "I'm just never going to get this or I'm never going to understand it."

Lana's ideas about learning that she developed in outreach helped prevent her from getting discouraged in her own learning.

Six undergraduates expressed interest in doing more university outreach, including two graduating participants who said they wanted to be involved in outreach during graduate school. Susan said, "I'll really want to join a group [in graduate school] who does some form of their own outreach." Although not specific to science outreach, for Wilson, outreach made him want "to do a lot more volunteer stuff."

Seven undergraduates reported that participating in outreach improved their understanding of the K-12 education system. Andy said that he "got to know more about the school system… because you're out there at the school and you meet teachers and stuff." He was able to see what classroom teachers "were focusing on" in terms of science content. Lana became aware of disparities in education because of the variety of schools served by Chemistry Outreach. She explained further:

> We see private schools, we see schools from wealthy areas, we see schools from disadvantaged areas, we see schools where all the kids are White, schools where all the kids are Hispanic, and it's so evident when some classrooms just haven't had the same resources as others.

The undergraduates gained a better understanding of factors affecting K-12 teaching, such as standards, curriculum, and diversity issues.

In addition to gains related to their overall academic experience, 10 undergraduates discussed improvements in their science content knowledge. For some undergraduates, outreach helped them better understand what they were learning in their undergraduate courses. Larry reported:

> I'm learning about a lot of stuff [in class] that's also done in the [outreach] program and a lot of our example experiments or whatever, they're actually performed by our professors in lecture. So they actually reflect stuff that I'm learning about. And I guess it kind of helps to see it, especially if you're performing it, you get a lot better understanding of what you're doing than if somebody else is doing it.

For others, working in outreach helped refresh and improve their knowledge of basic concepts. For example, Amanda said, "I used to think that I was pretty knowledgeable in basic science, but I found out pretty quickly that I had lost a lot of that basic science content." She also found that by "teaching these kids so much basic science content, I'm starting to draw connections between things."

Furthermore, three of those undergraduates felt that outreach increased their interest in science (and desire to remain a science major). As Lana said, "I think I just gained more enthusiasm for science or at least like retained it, I think it's really easy to get burnt out as a science major in college." After describing a time when she felt particularly burnt out, Lana said that "being able to stay passionate about science just using outreach as an outlet was incredibly important at that time."

Personal gains. Participating in outreach also led to personal gains for the undergraduates. Eight undergraduates reflected on how much they enjoyed working with outreach. They felt their experiences were fun. Undergraduates made statements such as "I can't explain how fun it's been," "It's just really fun for me," and "This is actually pretty fun and I just continued doing it whenever I had free time." Some undergraduates found doing science demonstrations and activities to be enjoyable. For example, Javan described:

> The experiments are really cool.… I know the chemistry behind every single experiment, but some of them, they're just so cool. Like who doesn't want to ignite a methane bubble and see a big fire, like they're just exciting and the fact that you're the instructor and you actually get to be the one handling it… you get to be the one doing it, that's like ten times more fun.

As Saraf said, "I'm a little kid at heart, I think [that's] why I like Let's Do Science so much… I just want to play, I just want to have fun."

Furthermore, eight undergraduates reflected on the rewarding nature of outreach. Larry remembered being on the other side of similar types of programs when he was younger. As he explained why he joined outreach, he said, "I felt kind of bad not giving back and giving the same opportunity for others that I had." He further said, "It's rewarding knowing you're making a difference and you're actually helping people out." Wilson found that "knowing that there are actually a couple kids that really, really, really enjoyed it, like it actually kind of made an impact on them, that's one of the best feelings in the world."

Undergraduates also reported that outreach was a nice break from their studies. Beth described outreach as "a great break from school… it's just a nice break in the day where you don't have to be writing a paper or studying for a midterm." Lana said, "It's really nice… especially in the middle of kind of your harder years as a chemistry major where you're overwhelmed with physics and math and o[rganic] chem[istry]… it was really nice to kind of take a break." Outreach also provided them with an opportunity to interact with different age groups and populations. For Susan, outreach was an opportunity to work with "a more diverse populace" because, as she described, "in college you're in this bubble with your peers… like who you live with, who you eat with… just surrounded by 18- to 23-year-olds almost all the time." Outreach provided her with the opportunity to work with children and adults outside her normal age demographic.

Research Question 2: What Ideas About Science Teaching and Learning Do Undergraduates Develop From Participating in Outreach Programs?

The four themes that emerged related to undergraduates' ideas about teaching and learning science were understanding students,

the nature of science and scientific practices, active learning, and student interest. The number of undergraduates who discussed each code subject and relevant examples are provided in Table 5. Each theme is discussed below.

Table 5. ***Themes and Codes Related to Undergraduates' Ideas About Teaching and Learning Science***

Themes/Codes	Description	*n*	Example quotes
Theme 1: Understanding Students			
Levels—assess	Assess, determine, gauge students' level (of understanding) from where they're starting	7	"You have to know where your students are starting from before you can even convey any information."
Adapt	Adapt or adjust, tailor explanations/teaching to students' level of understanding	7	"When people don't get it the first time, just like trying to come up with a new way to look at it and motivate them to keep trying."
Students differ	Understand when teaching that students are different, differ in levels of understanding, background, context (even at same grade level)	8	"Some of the kids are more visual, some of them are more hands-on."
Theme 2: Scientific Practices/Nature of Science			
Science practices	Importance of teaching or including inquiry, experiments, scientific thinking, science process/methods in teaching; students learn better by doing science (science practices)	5	"I think that one's really effective because not only are they seeing what's going on… they're also experiencing the scientific method."
About science/ science unique	Importance of teaching about science as a discipline, including addressing perceptions of science & scientists; learning science is different than learning other subjects	4	"Science really is not this thing where it's just White guys in lab coats."
Theme 3: Active Learning			
Hands-on	Students learn better by doing activities/hands-on work; important to include hands-on activities in teaching	7	"You get to play with the cool thing, and then after doing that for ten minutes you have a better understanding… you can recall those memories from when you were playing around with something physically."

Demo	Demonstrations of scientific phenomena concepts are effective for teaching and learning	7	"Show a quick demonstration on how it actually works."
Student participation	Important that students participate, are involved with lesson (e.g., asking questions, making predictions); interactive	8	"I used to think that teaching was more like, 'Oh let me stand here and tell you about it' instead of really having them really interactive with the guide [instructor]."
Theme 4: Student Interest			
Engage/excited	Important to get students' attention, make them curious, interested; for students' attention, make them curious, interested; for students to learn, important that students are excited/interested	8	"I think they definitely learn it better if you make it interesting."

Note. n = Number of participants who discussed code topic.

Understanding students. Through participating in outreach programs, the undergraduates realized the necessity of understanding the K-12 students' prior knowledge and how to adapt their teaching to meet students' prior knowledge and needs. They also recognized that students learn differently and come from many different contexts.

While working with K-12 students in outreach, undergraduates found that they needed to choose appropriate explanations for the level of their students. For example, Wilson acknowledged that "working with kids kind of helps me to understand them a little bit better, so I can kind of gauge how intricate or what level of an explanation I can give them and they'll still understand it." Likewise, Janelle said, "I can understand now why teaching is so hard because there's such a broad range of understandings in one subject; you have to tailor your explanations to fit everyone's needs." Wilson, Janelle, and others recognized that they needed to choose their explanations based on student levels of understanding.

Undergraduates also spoke of the need to first assess what students already know about a concept to determine the appropriate level of explanation. Javan realized that "you have to know where your students are starting from before you can even convey any information." Similarly, Lana noted that when she first started Chemistry Outreach, she felt frustrated that students did not seem

to know "basic concepts that they were kind of expected to know," but for her, "now it's kind of more my attitude to just try and assess where the students are at as early as possible and teach them as much as I can."

In accordance with determining students' current levels of knowledge, undergraduates also found they often needed to adapt their explanations or teaching strategies. Javan described how he had to adapt during his outreach experience:

> I feel you really have to think about how they're seeing things and that's the most difficult part, I kind of found that out the hard way because in the beginning, the overseeing professor kept telling me that I'm explaining things too difficult, like I'm going way over their heads, I think it's because I'm explaining things the way I know them now but not how I knew them in fifth grade. I think that one thing is really taking a step back and seeing how your students are going to look at you and you have to be able to take that view and be able to alter your explanation so it's understandable by them.

Undergraduates, like Javan, learned how to change their instruction so the K-12 students could better understand their explanations.

Eight undergraduates discussed the importance of understanding how students differ. Several of these undergraduates thought that students learn differently and witnessed different types of learners during their outreach experiences. Susan explained:

> [I] just kind of realized that there's a diversity of learning types… I mean I've heard that before and so I recognized it maybe in myself some, but just having, witnessing a whole class of students trying to build something you really see the diversity, it's not just something they say, it's really true.

Susan observed the different ways middle school students approached a building task and developed the idea that students differ in how they work and learn.

Furthermore, the undergraduates recognized the need to consider students' backgrounds and differences when teaching. For example, Cameron said:

> You have to understand the context that the kids are in.… So knowing where they come from as well, so if they're more inland, you know they won't have that much familiarity with the beach, so just knowing those kinds of things, where they come from, how far they come from, those are really, really important things to know.

Susan experienced how students bring their unique backgrounds and interests into their learning. She described, "At the end of the solar car workshop they're asking ways to improve the car and some kid said some term… some like injection thing that they have on race cars or something… that's just like kids bring their own knowledge to it."

Scientific practices/nature of science. Undergraduates discussed the importance of teaching inquiry, scientific thinking, and scientific processes or methods. Undergraduates felt that students learn better by "doing science" or by participating in scientific practices. They also discussed the importance of teaching about science as a discipline to address misconceptions about science and scientists, and that learning science is unique because of the nature of science.

Four undergraduates noticed that aspects of their outreach programs that allowed K-12 students to engage in scientific practices were particularly effective. For example, in describing an effective station from her outreach program, Amanda said:

> We ask them to make a hypothesis about where these beach hoppers [insects] live, and they each have to write down a hypothesis and then we do a full experiment and we try to catch the beach hoppers and they love it, they're pulling up the rack and they're counting the beach hoppers in the sand and it's, I think that one's really effective because they're like, not only are they seeing what's going on and they're learning about it, but they're also experiencing the scientific method.

She found that having the fifth graders participate in scientific practices such as making hypotheses and collecting data added to their overall learning experience. Lana stressed the importance and value of teaching scientific thinking skills, which are useful beyond science. She explained, "Teaching them the scientific method and

how to approach problems like scientists is going to be a valuable skill no matter what kids want to do."

Undergraduates also emphasized the importance of addressing student misconceptions about scientists and science as a discipline. For example, Cameron explained how the MREP outreach program addresses these misconceptions:

> Well, one thing for me is that science is not a standalone subject. It is like so mixed in with every other subject that you can think, and a lot of the misconceptions that students come in with, like it's the really unobtainable concept-based subject that you can't really get into, when really what we try to do is to show them that science really is not this thing where it's just White guys in lab coats, so it's everything from things with engineering and biology and that kind of stuff. So it's not just something that is science in a lab, it's everything out there.

Cameron hoped that students participating in the outreach program would recognize that science was all around them and that anyone could be a scientist.

Undergraduates also described the uniqueness of science as a discipline and as an academic subject. Javan commented on the unique characteristics of science and science education: "I don't think that there's any other subject that particularly incorporates that idea of curiosity and inquiry as the forefront of how you learn, so I think that's what's characteristic of science education." Saraf also commented that the empirical nature of science separates it from other disciplines and thus affects how to teach science. He felt that the nature of the Let's Do Science outreach program "reinforces the fact that it [science] is a process and it shows that it's different than any other type of learning."

Active learning. In addition to thinking that engaging in the practices of science is important for learning science, undergraduates also frequently discussed the importance of active learning in general. They felt that students learn better by performing hands-on activities, watching and interacting with teacher demonstrations of scientific phenomena, and actively participating in more lecture-style lessons.

Seven undergraduates cited the effectiveness of student participation in "hands-on" activities—activities such as building solar cars, collecting organisms outdoors, or dissecting fruits. Janelle

noted, "Kids really love hands-on things, like if they can touch it, if they can see, if they can smell it, and be like 'Eww, it's so gross,' they love it." She further commented, "We're very touchy beings, but it's kind of interesting as we grow older we learn not to be as hands-on about things, like that's kind of a strange education system."

Furthermore, Amanda compared the effectiveness of an active hands-on station to a less active, "hands-off" station in Nature for Kids:

> One of their [fifth graders'] favorite, favorite stations is the invertebrate station, and we, what we do at that station is we literally give them nets and give them a little bucket and say go find stuff in the creek, and they go crazy, they're so excited and they're scooping up all these things, they want to know what they've caught… I literally don't think I've had one student that didn't like doing that.… Then an example that definitely wasn't as effective, we had a plant adaptation station and all it was was a blue tarp on the ground and they would sit on it and we would show them different plants, and they just did not absorb it at all.

After comparing the fifth graders' reactions to the hands-on and hands-off stations, Amanda felt that they were more enthusiastic about the hands-on station and did not retain as much information from the hands-off station.

Seven undergraduates indicated that demonstrations of scientific phenomena were important for student learning and getting students' attention. For example, Susan explained,

> Demos and stuff really get kids involved; I think that's a better way to do it. Because like, when you're just talking at the beginning, maybe not everyone's paying attention, then if you do a cool demo you get their attention and they're more interested in it.

Wilson commented that "it's always a good idea to show what you're doing, like you can't just explain it to them."

Besides being actively involved with hands-on activities and demonstrations, eight undergraduates discussed the importance of interactive lessons where students participate by asking and answering questions, making predictions, and deducing concepts on their own. For example, Cameron described how MREP encour-

ages student participation through questioning: "So what we try to do is we're really into questioning, so we don't just lecture… as the tour goes on, all of the stuff that we're teaching, we're teaching it through questions." Lana explained how she encouraged student participation in Chemistry Outreach by "asking the kids to yell out kind of the key points of the stations." In the same outreach program, Javan tried to get students to make predictions. Wilson also described how they have students make predictions and involve students in demonstrations in Physics Is Fun.

Student interest. The undergraduates also noted that K-12 student interest is important for learning science. From a learning perspective, undergraduates thought that K-12 students needed to be excited about or interested in what they are learning. According to Saraf, "When they're excited, that's when the learning happens." Similarly, from a teaching perspective, undergraduates thought that engaging students (stimulating their curiosity, getting them interested in the subject matter) was an effective teaching strategy. Javan explained, "The more curious they are, the more willing they are to learn and the better they're going to learn from me." Larry described how a teacher's excitement can foster student excitement: "I think it's like if you yourself get excited about what you're teaching, that'll get them also focused… and then the students kind of like tune in on it and they get excited about it too."

One way the undergraduates piqued the K-12 students' interest was by relating concepts to "real life." Seven undergraduates discussed the effectiveness of relating material to the K-12 students' lives for both teaching and learning. From her outreach experience, Beth learned that "kids stick to something that they can relate to and something that they can own and that they come up with themselves." Undergraduates also felt that analogies and metaphors were useful for explaining concepts. Javan said, "Analogies work really well, I've gotten a lot better with creating analogies, it's kind of the easiest way to explain anything actually."

Table 6. ***Number of Undergraduates From Each Outreach Program Who Discussed Each Code Topic Related to Reported Gains (RQ 1)***

	Theme 1 Codes				Theme 2 Codes			Theme 3 codes		Theme 4 codes		
Outreach Program (Pseudonym)	Career—options	Career—development	Career—skills	Faculty	Interest — outreach	Reflect—own learning	Understand—education	Content	Explain science concepts	Break	Fun	Rewarding
Chemistry Outreach (*N*=3)		1	3	1	1	1	2	3	1	1	3	3
Let's Do Science (*N*=2)	1	1	1	2	1	1	2	3	1	1	3	3
Marine Research and Education Program (MREP; *N*=1)	1	1	1				1	1				
Materials Research Outreath (*N*=1)	1	1			1			1	1	1	1	1
Nature for Kids (*N*=1)	1	1		1	1	1	1	1			1	1
Physics Is Fun (*N*=2)		1	1		1	2	1	2	1	1	2	1
Family Science Night =+ MRO (*N*=1)		1	1		1		1	1	1			1

Table 7. ***Number of Undergraduates From Each Outreach Program Who Discussed Each Code Topic related to Ideas About Teaching and Learning (RQ 2)***

	Theme 1 Codes			Theme 2 Codes		Theme 3 Codes			Theme 4 Codes	
Outreach Program (Pseudonym)	Levels—assess	Adapt	Students differ	Science Practices	About Science/science unique	Hands-on	Demo	Student participation	Engage/excited	Relate
Chemistry Outreach (*N*=3)	3	3	1	2	2	2	1	2	3	2
Let's Do Science (*N*=2)			1	2	1	2	1	1	1	2
Marine Research and Education Program (MREP; *N*=1)	1	1	1		1		1	1	1	2
Materials Research Outreach (*N*=1)		1	1			1	1	1		1
Nature for Kids (*N*=1)			1	1		1	1	1	1	
Physics Is Fun (*N*=2)	2	1	2			1	1	1	2	1
Family Science Night + MRO (*N*=1	1	1	1				1	1	1	

Research Question 3: How Does the Type of Outreach Program Affect Undergraduate Outcomes?

For Research Question 3, to examine how different programs resulted in the above outcomes, I separated the themes and underlying codes by outreach program. The frequency counts for each code (from Tables 4 and 5) were broken down by outreach program. Since Andy participated in two outreach programs, there is a program category that combines these two programs (Family Science Night and Materials Research Outreach). Table 6 shows the codes related to participant gains by outreach program, and Table 7 shows the codes related to ideas about teaching and learning by outreach program.

Overall, as seen in Tables 6 and 7, undergraduates from different programs discussed each code. In other words, the occurrences of a single code did not all fall into one outreach program. This provides further support for the results of Research Questions 1 and 2 in that participation in outreach, regardless of program, can result in these outcomes. Thus, there are commonalities in undergraduates' experiences of science education outreach independent of the type of program.

The sample size is too small to establish specific relationships between the type of program and outcome. Furthermore, the differing numbers of informants per outreach program made it difficult to determine patterns. However, this breakdown indicates potential variables associated with the type of program and possible relationships to further investigate in future research. For example, undergraduates from Chemistry Outreach reported nearly all of the same gains as respondents from Let's Do Science, except for knowledge of career options. The purposes and operation of these programs are quite different, but the programs are overseen by the same department at the university. Perhaps program administration is an important variable to explore further.

These data indicate that other characteristics of the programs may affect undergraduate outcomes, such as whether the program has corresponding coursework or employment opportunities. Outreach programs can have components beyond the direct interaction with K-12 students in which the undergraduates participate. For example, participating in outreach can have accompanying coursework, be a form of employment, or involve concomitant duties.

Comparing the responses from the undergraduates in Nature for Kids (NFK) and the Marine Research and Education Program (MREP) shows that a program's associated coursework, employment, or other duties may be factors that affect certain undergraduate gains. NFK has a related class and MREP is more like a job with duties (e.g., maintaining the aquaria) other than educational outreach programs. As shown in Table 6, the two undergraduates from these programs did not discuss gaining improved abilities to explain science concepts to general audiences (the "explain science concepts" code), whereas undergraduates from all the other programs did. With coursework and job duties, perhaps there are not as many opportunities to develop this skill.

Neither undergraduate from NFK or MREP described outreach as providing a break from school (the "break" code), whereas undergraduates from other programs did. NFK and MREP are both long-term programs with expected long-term commitments from the participants. Amanda (from NFK) and Cameron (from MREP) both participated in their respective programs over multiple years and for over 100 hours (see Table 1). This might indicate that the amount of time spent participating in outreach contributes to how much undergraduates perceive outreach as a break from school; however, Lana (from Chemistry Outreach) and Beth (from Let's Do Science) also participated in their programs over multiple years for well over 100 hours (see Table 1), and both discussed outreach as providing a break from school. Thus, perhaps a program's associated coursework, employment, or other duties (rather than the number of hours spent participating in outreach) contribute to whether or not outreach provides a break from school. Undergraduates may not feel that outreach is a break from schoolwork if they participate in programs like NFK that have a coursework component or programs like MREP that require duties beyond educational outreach.

Interestingly, the undergraduate from MREP, a program with employment opportunities and other duties beyond outreach, discussed all the career-related codes but none of the personal gain codes ("break," "fun," and "rewarding"). It makes sense that a program like this would foster career gains and possibly be less likely to foster personal gains.

The degree to which a program focuses on scientific content versus scientific practices or inquiry is another factor that may affect the ideas undergraduates develop about science teaching and

learning. As shown in Table 7, no undergraduates from Let's Do Science or Nature for Kids mentioned the importance of assessing the K-12 students' prior knowledge or adapting instruction to meet student levels and needs ("levels—assess" and "adapt" codes). Let's Do Science is focused more on scientific practices (e.g., designing experiments) than on scientific content. Overall, the undergraduates who discussed these topics seemed to focus on assessing or adapting to student levels of content knowledge rather than knowledge about scientific practices. Undergraduates participating in a program like Let's Do Science may not develop ideas about assessing and adapting to students' prior knowledge since they do not recognize the need to do so with student knowledge of scientific practices, and they do not need to assess or adapt to levels of student content knowledge. Other programs, such as Chemistry Outreach and Physics Is Fun, do aim to convey specific scientific content, and undergraduates in these programs did report the need to assess and adapt their teaching to meet the K-12 students' prior knowledge. In contrast, Nature for Kids is content-based but also emphasizes student involvement in scientific practices, so perhaps the degree to which a program focuses on content versus scientific practices affects the ideas that undergraduates develop.

Additionally, no undergraduates from Materials Research Outreach, Physics Is Fun, nor the undergraduate from FSN+MRO discussed the codes related to the Scientific Practices/Nature of Science theme. This makes sense since these programs do not have a strong focus on scientific practices or inquiry. However, undergraduates from Chemistry Outreach did discuss these topics, although this program does not seem to have a strong focus on scientific practices. Again, it is important to further investigate how a program's degree of focus on content versus scientific practices affects the ideas about teaching and learning that undergraduates develop.

Discussion

This study provides evidence of important impacts on undergraduate participants in science education outreach to K-12 schools. The undergraduates in this study participated in various outreach programs and reported career gains, academic gains, gains in scientific knowledge, and personal gains. The undergraduates also developed ideas about learning and teaching science, including ideas about understanding students, scientific practices, active learning, and student interest. These outcomes were fairly consistent across outreach programs; however, this research also

points to programmatic elements that may affect undergraduate outcomes. Further research is needed to explore these elements.

Limitations

This research has limitations. The sample of undergraduates interviewed was a self-selecting group. All the interviewees reported positive experiences with outreach. Undergraduates who have had negative or neutral experiences with outreach may be less likely to respond to a request to be interviewed about their experience. By conducting interviews, I examined undergraduates' perceptions of what they gained and learned from outreach programs. This was not a rigorous assessment of their knowledge or of particular pre–post changes in knowledge. Also, although they were specifically asked what they gained or learned from their experiences with the particular outreach program, the undergraduates' ideas on teaching and learning science could have been influenced by factors outside their outreach experience.

Additionally, if an informant did not talk about a certain code, this does not necessarily mean the informant would disagree with the code or not have ideas on the topic. The interview questions were open-ended and broad, allowing informants to freely discuss any ideas they had in response to the questions. The codes and themes were generated from the data, and codes were not specifically linked to certain interview questions. For example, informants were asked broad questions, such as "What did you gain from your experience?" and "What have been the most beneficial experiences for you?" Although four informants discussed the unique opportunity to work with university faculty, this does not mean that other informants did not have the opportunity to work with faculty or that they did not find working with faculty important. The informants were not specifically asked if they had opportunities to work with faculty or if that was an important part of working in outreach. However, these findings indicate that working with faculty may be an important outcome of participating in outreach programs and that examining faculty involvement is something to consider in future research.

This research examined only one side of university–K-12 outreach partnerships. These partnerships are reciprocal, meaning that both sides are benefiting (*James et al., 2006; Williams, 2002*). How university K-12 science outreach impacts K-12 participants and how these partnership systems function as a whole was beyond the scope of this study. More research is needed on these topics.

Implications

The results of this study promote the research-based development, refinement, and dissemination of effective university outreach programs. For example, program administrators can use the findings of this study to provide rationales for including more undergraduates in science outreach as well as to recruit more undergraduates to their programs. This study shows that K-12 science outreach is an effective experiential learning opportunity for undergraduate science majors. Participating in K-12 science outreach can enhance undergraduate science majors' university experiences by providing enjoyable and rewarding opportunities to increase their understanding of science, work with university faculty, reflect on their own learning, and have positive breaks from regular schoolwork. In addition, outreach experiences can expose undergraduates to diverse populations and increase their awareness of and interest in education and other careers. They can also develop important ideas about teaching and learning science.

As mentioned, much of the previous research on university outreach has focused on graduate students. Findings from this study on undergraduates (such as career-related skill development, clarification of career options and interests, enhanced content knowledge, and increased understanding of educational issues) are consistent with research on graduate students (*deKoven & Trumbull, 2002; Laursen et al., 2007; Moskal et al., 2007; Page et al., 2011; Stamp & O'Brien, 2005; Thompson et al., 2002*). For program administrators, these convergent findings elucidate how university–K-12 science outreach programs benefit the university participants. However, other findings in this study are particularly pertinent to undergraduates. For example, the opportunity to work with faculty is significant for undergraduates who typically may not have that opportunity, particularly at large research universities.

This study also examined ideas about teaching and learning science that undergraduates develop from participating in science outreach. Previous studies have not included this element. Undergraduates in this study recognized the importance of understanding students' prior knowledge and how students differ. They also became familiar with teaching scientific practices, active learning, and the importance of student interest. Whether the undergraduates who participate in science outreach become K-12 teachers or university faculty, or just continue educating through outreach, they represent future science educators. Findings from this study are evidence that K-12 outreach can play an important role in preparing science educators. This is similar to how service-

learning has been used in teacher education programs (*Brannon, 2013; Cone, 2012; Harlow, 2012; Vavasseur et al., 2013; Wallace, 2013*).

Some programmatic elements may affect undergraduates' outcomes, such as corresponding coursework or employment and the degree to which a program focuses on content versus scientific practices or inquiry. Identifying elements of outreach programs with beneficial outcomes for undergraduate participants can lead to the development of programs that utilize those elements. More research is needed to further identify these elements and their effect on undergraduate outcomes. Likewise, further research is needed on factors other than programmatic elements: for example, factors related to the undergraduate participants themselves, such as the number of hours they have participated in outreach, their reasons for participating (goals and interests), and their specific roles in the programs. Furthermore, the long-term impacts of participation need to be investigated. Laursen et al. (*2012*) demonstrated that participating in outreach can have lasting impacts on graduate student career choices. However, the long-term effects of outcomes for undergraduates have not been explored.

Currently, outreach programs are typically peripheral programs with only a minority of undergraduate science majors participating. Williams (*2002*) suggested that research should focus on measuring the impacts of outreach on university participants, and that measurable positive impacts "could move these outreach activities from peripheral programs to integral components of the university" *(p. xxi)*. Thus, studies such as this one that document the benefits of participation in outreach could help outreach become an integral component of undergraduate science education.

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