Launching Sustainability Leadership: Long-Term Impacts on Educational and Career Paths in Undergraduate Research Experiences

By Wendy Griswold

Undergraduate research experiences (UREs) are valuable in developing students’ science and technical skills and clarifying career paths in the short term, but sparse research examines their long-term impacts. This exploratory study also examines their potential for developing sustainability-minded professionals to address our increasingly serious and complex global environmental issues. Survey research on URE participants 4 to 9 years later focused on programmatic impact on their educational and career paths and current sustainability engagement. Key results were that past participants considered their URE impactful on decisions to pursue graduate studies and on career choices and attributed part of their success in graduate school and careers to it. Moreover, many participants were working in sustainability-related careers, carrying out the roles they envisioned for themselves as undergraduates. These participants identified themselves as sustainability leaders and were more likely to identify their sustainability role as educators or problem solvers than those without sustainability-related careers. Several had maintained connections with past program participants, creating an ongoing support network of sustainability-minded peers.

We live in an era in which it is increasingly apparent that climate change is a threat to humanity. We need professionals with the values, knowledge, and skills to implement solutions to the threat of climate change and other serious environmental issues (Graedel & van der Voet, 2010; Roorda, 2012). Sustainability, first defined by the Brundtland Commission as “development meeting the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987, p. 43), is a concept and a range of practices that would address this threat. Hull, Kimmel, Robertson, and Mortimer (2016) identified the need for professionals with sustainability mindsets and skills as a growing workplace demand. The formal education of scientists, engineers and other professionals is one important pathway for developing needed sustainability-minded leaders and decision-makers, but technical and content knowledge should be bolstered by leadership capacity to facilitate the social and cultural changes necessary to develop sustainable societies (Wiek, Witycombe, & Redman, 2011). Extra- and co-curricular programs, such as undergraduate research experiences (UREs), may have a role in developing sustainability leadership, in addition to supporting future professionals pursuing science and engineering careers.

Several studies have explored short-term URE benefits. Common key findings include the following as benefits: increasing knowledge about conducting research, growing confidence in research skills, clarifying future career and educational paths, and developing identity as a scientist (Grimberg, Langen, Compeau, & Powers, 2008; Hunter, Laursen, & Seymour, 2006; Lopatto, 2007). Although research on UREs’ effectiveness among active and recent participants is well documented, there are few studies on their long-term impacts. Harsh, Maltease, and Tai’s (2011) multi-institutional, mixed-methods study uncovered long-term effects of URE participation on practicing chemistry and physics scientists. Their study concluded that exposure to research, increased confidence in research skills, and development of laboratory skills were viewed by participants as benefits with lasting career impacts. Yaffe, Bender, and Sechrest (2014) compared participants and nonparticipants in undergraduate research within a single institution. Key findings were increased clarity and confidence in pursuing science careers and higher levels of career satisfaction among URE participants. Both studies identified mentors as
key factors in pursuing research careers. These studies provided evidence that URE benefits identified by short-term studies do indeed impact participants’ choices about education and career paths. However, they are limited by their general focus on science/technical career paths.

Research is needed on the long-term impact of UREs focused on developing sustainability mindsets and pursuing sustainability careers. Griswold (2017) and Erickson, Griswold, Hohn, and Saulter (2010) demonstrated the short-term effectiveness of such programs on expanding participants’ concepts of sustainability, supporting identity development, and the role of learning communities in those processes, but documentation of long-term impacts is lacking. To begin addressing this, an exploratory, long-term follow-up study was conducted to learn whether a sustainable energy URE was viewed by participants as impacting their educational and career paths and continuing involvement in sustainability leadership. Program participants from 2009 to 2014 were invited to help investigate the hypotheses that they perceived their experiences in a sustainable energy URE impacted their (a) educational paths, (b) career paths, and (c) ongoing engagement with sustainability.

**Study description**

This exploratory descriptive study documented participants’ personal experiences in a sustainability-focused URE 4 to 9 years afterward. The program and current study were funded by the National Science Foundation’s (NSF) Research Experiences for Undergraduates (REU) program, which supports undergraduate research in any NSF-funded research area. This URE focused on sustainable energy research, including mentored research, sustainability seminar, field trips, research meetings and culminating symposium, professional development seminars, brownbag discussions, group projects, reflective journaling, and a community-wide sustainability dialog.

**Participants**

Using purposive sampling, 18 program participants were recruited out of a total population of 59. Participants from each program year (2009–2014) were represented. Participants included 13 women and five men, with 13 identifying as Caucasian, three as Asian, one as African American, and one as Hispanic. During their REU experience, all were pursuing STEM (science, technology, engineering, and mathematics) degrees at a variety of U.S. institutions. Most study participants only participated in one REU as part of their undergraduate experience.

**Methods**

A descriptive survey documented participants’ self-reported educational paths and career choices/opportunities and examined the influence of URE participation on said paths and choices. The survey included questions on the usefulness of the experience on education and careers and involvement in sustainability activities and leadership. Participants were asked to rank URE participation benefits. Questions reported here included 12 yes/no items collecting descriptive/demographic information, 15 five-point Likert items to determine perceptions of influential experiences and sustainability leadership, 10 rank order items related to program benefits, and nine open-ended responses to gather data on individual experiences and paths. Prior research on this REU (Erickson et al., 2010; Griswold, 2017) and undergraduate research experiences in general (Harsh et al., 2011; Yaffe et al., 2014) informed survey development. Content validity was established through program review by faculty, directors, and evaluators. The survey was administered using Qualtrics. Quantitative data were analyzed using SPSS. Content analysis was used on qualitative data generated by open-ended questions.

**Results**

Results are organized into three categories: graduate study and career paths, sustainability careers and leadership, and other long-term benefits.

**Graduate study and career paths**

This study supported Harsh et al.’s (2011) and Yaffe et al.’s (2014) findings on the long-term impact of UREs on participants’ graduate study and career paths. Sixty-one percent of participants are currently enrolled in or have attended graduate school. By comparison, URE host institution data from 2009 to 2014 show that 13% of students earning undergraduate degrees in STEM fields went on to complete master’s or doctoral degrees (Kansas State University, 2018). Five are currently working toward a doctoral degree, one is pursuing a master’s degree, and one a JD degree. Of those who completed degrees, two received a master of science degree, one a master of engineering degree, and one a PhD. Fields of study include agricultural/biological engineering, chemical engineering, computer science, energy resources engineering, immunology, law, mechanical engineering, and public policy. Of those who are attending or have attended graduate school, 91% reported that the URE was very (55%) to somewhat (36%) influential in that decision. Seventy-three percent reported that it was extremely (55%) to very (18%) useful in graduate school acceptance and extremely (18%) to very (55%) useful in helping them succeed. Sixty-
seven percent of all participants reported the URE was very (39%) to somewhat (28%) influential in their career choice. In terms of getting a job, 50% reported it was extremely (28%) to very (22%) useful.

**Sustainability careers and leadership**

During their URE, many participants expressed intentions to be involved in sustainability careers and issues in the future (Griswold, 2017). This study found that 61% reported that their current job involves sustainability. For those engaged in such careers, 63% reported that the URE was very (36%) to somewhat (27%) influential in that decision. Examples of their professional involvement in sustainability include agriculture, energy efficiency, law and policy, remediation efforts, renewable/alternative energy, and water resources.

When asked to what extent they considered themselves leaders in sustainability efforts at work, 45% reported a great deal (18%) to a lot (27%). Although all considered themselves sustainability leaders at work to some degree, 54% reported the level of their leadership as moderate or lower. This could be due to their current position in the workforce. They are still in the early years of their careers and several are completing their educations, with many experiencing recent job changes, and they may not yet be in positions where they are comfortable or able to demonstrate higher leadership levels.

Participants were asked to what extent they saw their role in the following areas: setting an example for others by living a sustainable lifestyle, advocating for sustainability issues as a citizen, advocating for sustainability issues as a professional, informing/educating the public on sustainability issues, and developing sustainable solutions. Between 82% and 59% reported that they saw themselves as having responsibility or a role in each of these areas a great deal to a lot. Serving as an example (82%) and advocating for sustainability (70% as a citizen, 65% as a professional) were the strongest reported responsibilities. Most responses were in the middle to upper end of the scale (moderate or higher), with few responses indicating participants felt little to no responsibility in these areas. Figure 1 provides more detail.

To understand the impact of sustainability careers on roles, an independent samples t-test was conducted to compare perceived roles among participants with sustainability careers and those without. With respect to education, there was a significant difference between those in sustainability careers (73% [a great deal to a lot]; $M = 1.55$, $SD = 1.128$) and those not (29%; $M = 2.71$, $SD = .488$); $t(16) = –2.570$, $p = .02$. With respect to problem solving, there was a significant difference between those in sustainability careers (73%; $M = 1.64$, $SD = 1.362$) and those not in sustainability careers (43%; $M = 3.00$, $SD = 1.0$); $t(16) = –2.227$, $p = .04$. These results suggest that a career in sustainability impacts participants’ perception of their roles as educators and problem solvers when compared with those without sustainability careers. Participants’ sustainability roles were identified in a previous study (Griswold, 2017). During the program, participants’ concepts of their roles expanded from solely developing technical/scientific solutions to environmental sustainability challenges to the broader roles discussed previously. Findings in the current study indicate that participants have maintained this perspective 4 to 9 years later.

**Other long-term benefits**

URE goals included improving science/technical skills, increasing sustainability knowledge, participating in professional development, and gaining clarity about future career paths (Erickson, Griswold, Hohn, & Saulters, 2010). To determine how participants judged URE impact in these areas, they were asked about the usefulness of the experience with respect to each goal. Fifty percent reported that the URE was extremely (17%) to very (33%) useful in increasing confidence in science/technical skills. In increasing sustainability knowledge, 78% report-
ed the URE was extremely (39%) to very useful (39%). Sixty-seven percent reported that the URE was extremely (17%) to very (50%) useful in professional development, and 56% said it was extremely (28%) to very (28%) useful in developing clarity about future career paths.

Participants were asked to rank order URE activities by how beneficial they were on a scale of 1–10, with 1 being most beneficial and 10 being least beneficial. Responses are presented in order in Table 1. The top three responses were exposure to genuine scientific research, developing writing/presentation skills, and building confidence to conduct research. These findings are similar to those of Harsh et al. (2011).

Participants were asked to share specific examples of how the experience was helpful. Following are some of their responses:

- It helped me work in a science-related field right out of college and determine I can best help expand access to renewable energy by becoming a policy-maker.
- I realized I did not want to pursue a career in engineering. . . . I realized I wanted to focus my critical thinking skills on social and educational solutions to global problems.
- I was encouraged to continue my education and pursue a master’s degree in geology. . . . That degree and research I was conducting . . . ultimately made me a candidate for my job.
- [This] was my first research experience that was largely independent, which was good preparation for graduate research.

These examples illustrate UREs’ potential in the long term to help participants develop clarity on future career paths, leading to further higher education, work in industry, policy making, and finding nontechnical solutions for global environmental issues.

An additional potential URE benefit is the development of relationships among research mentors, program directors, and participants. Past research (Harsh et al., 2011; Yaffe et al., 2014) reported on the value of mentor–student relationships. Such relationships potentially can support participants during their careers. However, participants in this study reported low levels of maintaining contact with research mentors (22%) and program directors (11%) and obtaining help from them in their careers: 28% reported being helped by research mentors and 17% by program directors, including through letters of recommendation, help with selecting and applying to graduate programs, and co-publishing. Participants reported higher levels of maintaining contact with other program participants. Sixty-one percent stayed in touch with participants they met during the program. Although this contact has provided limited assistance in their careers so far (11% reported receiving career help from a fellow participant), it has provided a supportive network. One participant shared that fellow participants “provide . . . different perspectives that help . . . clarify . . . career objectives.” Another shared that they are “shining examples in the field and . . . provided invaluable suggestions and advice.”

**Discussion**

These participants reported that UREs had a sustained impact. Most of the participants enrolled in graduate study and are working in science/technology fields directly or indirectly through law, policy, or public service at rates similar to those found in other URE research (Grimberg et al., 2008). They reported that their URE influenced their decisions to pursue graduate education and helped them be accepted to, and successful in, graduate programs. They also reported that the URE was helpful to them in entering their careers and being successful. Participating in actual research, developing communication skills, and building confidence as a researcher were identified as the most beneficial activities. Gains made in achieving program goals and participating in the program are still viewed as valuable and meaningful years later.

Beyond anecdotally supporting prior research on long-term UREs, this study sheds light on UREs’ potential to develop professionals with sustainability mindsets. Several years after participating in a sustainability energy-focused URE, many participants followed through on the intentions they set as undergraduates to be involved in sustainability careers (Griswold, 2017). For them, sustainability is not a passing fad or a phase, but an internalized value they are operationalizing. The roles they

**TABLE 1**

<table>
<thead>
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<th>Rank order of program activities by benefit to participants.</th>
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<td>Built confidence to conduct research</td>
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<tr>
<td>Influenced decision to explore other areas</td>
</tr>
<tr>
<td>Exposed to research group meetings/discussions</td>
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<tr>
<td>Developed basic laboratory techniques</td>
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<tr>
<td>Furthered interest in science</td>
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<tr>
<td>Applied principles learned in classes</td>
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<tr>
<td>Exposed to graduate students</td>
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envisioned for themselves in creating a sustainable society are roles they are taking on. Also significant is that many are maintaining a network of sustainability-minded peers. This peer network can potentially support them as they develop their capacity as sustainability-minded leaders with increasing opportunities to implement sustainable policies and practices. Creating spaces in which future leaders and decision makers can explore sustainability issues, gain skills and confidence in sharing their perspectives, and chart a course for action is a service that UREs may be able provide.

Although the findings of this study support the hypotheses that participants in a sustainable energy URE perceived their experience as impacting their educational and career paths and continued engagement in sustainability, they are tempered by many limitations. A possible sampling bias is that only participants who maintained positive perceptions about the URE chose to participate. Data is limited to self-reported information from a very small sample. More significant are the limitations of the survey instrument. Because of the exploratory nature of the study, the instrument included several questions that are not reported here. The survey length did not allow the inclusion of cross-check questions that would have improved the robustness of the findings presented. The study is also limited to one program offered at a single institution and does not compare the experiences of URE participants to nonparticipants, as this data was not obtainable.

Conclusions
This study adds to the sparse literature exploring long-term URE impacts. Although an exploratory study of limited scope, it demonstrates the URE potential in developing sustainability-minded professionals, which justifies a larger scale, long-term investigation into their role in encouraging sustainability careers and leadership development. This investigation should include a comparison of outcomes experienced by students who participated in sustainability-focused UREs and those who did not. Although growing in popularity, not all students have opportunities for URE participation. Continued research is needed to fully understand URE possibilities for a range of fields and learners.

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References

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