Enhancing Undergraduate Agro-Ecological Laboratory Employment through Experiential Learning

J. M. Grossman,* M. Patel, and L. E. Drinkwater

ABSTRACT We piloted an educational model, the Sustainable Agriculture Scholars Program, linking research in organic agriculture to experiential learning activities for summer undergraduate employees in 2007 and 2008. Our objectives were to: (1) further student understanding of sustainable agriculture research, (2) increase student interest in sustainable agriculture careers, and (3) use community service as a vehicle for learning. The three learning environments were on-farm and laboratory research settings, weekly meetings and field trips to discuss research and observe farming practices, and a service-learning project. We collected feedback from participants through a post-program focus-group style evaluation in Year 1 and pre/post individual evaluations with participants and a non-participant comparison group in Year 2. Students learned about linkages between research and practice within all environments. Farm visits were the primary learning site, specifically through observations of sustainable agriculture practices related to lab work and interactions with farmers. Students described how farm visits made lab work relevant; however, there were few instances describing how lab work was relevant to farming communities. Our preliminary findings from this pilot study suggest that participation in the program led to increased interest in sustainable agriculture careers and increased desire to pursue research in some students.

note

In recent years there has been a dramatic increase in the number of academic programs and courses in the fields of sustainable agriculture, organic farming, and agroecology (Grabau, 2008; Bhavsar, 2002), and in students interested in pursuing such options. In an effort to improve learning and motivate students, sustainable agriculture educators have devised creative means to engage undergraduates involved in these programs in "real world" learning through their academic experiences. An extensive survey of sustainable agriculture faculty suggests that the primary way students learn about agriculture is through experiences that link classroom to field work, engaging a broad range of actors within applied settings (Parr et al., 2007), a suggestion that has been verified in practice (Wiedenhoeft et al., 2003). Cohen et al. (1993) emphasize the importance of how learning takes place in multiple environments that are then combined to shape a "learning landscape." Examples of hands-on academic agricultural experiences can include internships, student farm-based activities, field exercises, and interactions with farmers. Since the overall number of undergraduate students majoring in and graduating from general agricultural fields has been steadily declining (Madewell et al., 2003), such approaches may be useful to both encourage students already excited about sustainable agriculture, as well as recruit new students from non-agricultural fields.

Impact Statement

Undergraduates interested in sustainable agriculture often discover this interdisciplinary field late in their undergraduate career, resulting in a need for multiple approaches to encourage deeper student exploration of this discipline as a career path. Here we describe our pilot program designed to enhance the learning experience of undergraduates employed in research laboratories. Researchers will find the suggestions offered in this article useful to move student learning beyond the traditional washing of glassware.

Service-learning, the act of linking students to community partners to address public needs while developing disciplinary competency, is a proven way to engage students in real-world learning. The concept of *service-learning* is commonly used in environmental science courses to successfully reinforce concepts, develop student values and skills, build student confidence, and address on-the-ground community problems (Leege and Cawthorn, 2008; Ward, 1999). Like in the environmental science discipline, service-learning has a unique place in sustainable agriculture due to the field's applied nature and opportunities for multidisciplinary applications. Some upper-level undergraduate sustainable agriculture courses base large portions of course content on service-learning to help train agricultural professionals to collaboratively solve targeted agricultural problems and implement systemic changes in agricultural systems (Jordan

J.M. Grossman, Dep. of Horticulture, Cornell Univ., 134A Plant Sciences Building, Ithaca, NY 14853 (currently Dep. of Soil Science, 4235 Williams Hall, Campus Box 7619, North Carolina State University, Raleigh, NC 27695-7619); L.E. Drinkwater, Dep. of Horticulture, Cornell Univ., 134A Plant Sciences Building, Ithaca, NY 14853; M. Patel, Dep. of Education, Cornell Univ. 433 Kennedy Hall Ithaca, NY 14853. Received 3 June 2009. *Corresponding author (julie_grossman@ncsu.edu).

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677 S. Segoe Road, WI 53711 USA

Abbreviations: PCR, polymerase chain reaction; SAS, Sustainable Agriculture Scholars; Y1, summer of 2007; Y2, summer of 2008.

et al., 2005). Others have had some success using smaller service-related activities in their classes, such as extension-publication style classroom writing assignments for a more public target audience (Motavalli et al., 2007). Whole curricula have even been designed that focus on immersing students in real life agronomic phenomena to help them direct their own learning and decide relevant theory to learn (Lieblein et al., 2005). We know that care also needs to be taken in service-learning project design to ensure a high level of student intellectual engagement so that students, academic advisors, and hosts agree together upon a useful product, identify specific learning goals, and carry out project design (Grossman and Cooper, 2005). Despite great strides in agricultural education, additional initiatives are needed at the college level that both involve students in sustainable agriculture research and bridge these research efforts to larger socioeconomic contexts.

Here we explore the idea of translating hands-on learning activities from the for-credit course, where experiential learning is commonly applied, to other academic settings, such as employment. Many laboratories that focus on sustainable agriculture research questions typically hire undergraduate student employees to assist with project tasks. However, such students often do routine work with minimal intellectual engagement in the research process and do not learn about the larger context of the agricultural system in which results of their work will be applied. This results in students gaining research skills, but limits their scope of understanding about the broader context of sustainable agriculture and the issues facing farmers today. If the employment experience is seen as "boring" or otherwise negative, it can have the unfortunate effect of discouraging talented students from pursuing careers in either research or agriculture.

We argue here that undergraduate student employment offers a unique opportunity to recruit individuals who have expressed an interest in learning about sustainable agriculture and cultivate further learning and excitement about this field. In response to the need for experiential learning in sustainable agriculture education, we piloted a novel undergraduate educational model, the Sustainable Agriculture Scholars Program, designed to promote undergraduate excitement about the potential of sustainable agriculture research and career options through hands-on experiences. We borrowed from the concepts of service-learning and experiential education to develop a model program that engaged students in learning through their summer employment opportunities. Our program involved students directly in on-farm and laboratory research, structured weekly meetings to discuss sustainable agriculture research and agricultural career options, and a service-learning project with an agricultural organization. This article reports on the successes and challenges we encountered in the first two years of our program's implementation and provides guidance for those wishing to replicate the model in similar programs.

Objectives

The objectives of our pilot program were to: (1) further student understanding of the role of research in supporting sustainable agriculture, (2) increase student interest in sustainable agriculture career options, and (3) use community service as a vehicle for learning.

Methods and Materials

A program coordinator was chosen to facilitate the organization of the pilot program. A faculty member supervised the coordinator each year and was involved in all program decision-making. We recruited Sustainable Agriculture Scholars in the summer of 2007 (Y1) and 2008 (Y2) through advertising to selected departments at Cornell University. Agricultural, natural science, social science, and communication related departments were targeted using email and posters as the main form of marketing. Applicants were interviewed in person, and made aware of the SAS program's goals and objectives prior to their hiring as temporary employees. Funding (USDA-CSREES Integrated Organics Program) allowed us to hire a total of six students (three each year) who were paid the standard hourly rate for summer employees at Cornell University for all time committed to program activities, amounting to a 40-hour work week. The three major learning environments were (1) on-farm and laboratory research settings, (2) structured weekly meetings and field trips to discuss research and observe sustainable farming practices, and (3) a facilitated service-learning project with an agricultural organization.

Methods Learning Environment 1: On-Farm and Laboratory Research

The laboratory in which students were employed conducts studies of soil nutrient cycling processes in agroecosystems. Within this context, students engaged in routine research activities such as plant and soil collection, sample preparation (grinding, weighing), root washing, bacterial extraction from root nodules of legumes, polymerase chain reaction (PCR) and gel electrophoresis, microbiological culturing, and dishwashing. Students conducted research-related activities for 8 hours each workday for 4 days each week. The fifth workday was set aside from laboratory activities and dedicated to the students chosen service-learning project.

Methods Learning Environment 2: Farm Visits and Weekly Discussions

Each week participants met in a structured multidisciplinary environment consisting of either a classroom-based facilitated presentation/discussion, or a field trip to an organic farm. As a pilot program, activities changed slightly from Y1 to Y2 in response to student feedback. Farms were chosen in Year 1 to present the diversity of agricultural settings, and in Year 2 to focus on legume cover crops, a primary topic of the laboratory research. Discussions and activities were led by farmers, faculty, post-doctoral researchers, and graduate students. Weekly discussions were also used to discuss career options in agricultural sciences and ways in which students can best prepare to be a strong candidate on the job market. Attempts were also made to involve graduate students as mentors during lab activities by encouraging informal discussions about career goals and the graduate students' own academic paths.

Methods Learning Environment 3: Service-Learning in Sustainable Agriculture

A third key feature of the Sustainable Agriculture Scholars Program was an experiential learning and service component linking summer Scholars to local agricultural issues and topics. Projects taking place outside the realm of their laboratory activities were strongly encouraged. During the program orientation students were offered an initial list of possible service hosts. This list included nonprofit organizations, county and state extension offices, volunteer programs, commercial farms, and grade school classrooms interested in developing agricultural curricula. Scholars then identified a project in an area of interest to them. Hosts were offered no compensation for supporting the work of the student. Students continued to be paid on an hourly basis for service project activities, supported by the external grant. Students were expected to initiate contact with the host, describe the goals of the Sustainable Agriculture Scholars program, and negotiate a project that was mutually beneficial to the host and student. Students then worked with the SAS program coordinator to develop a "learning contract" that outlined these mutual expectations in writing (Appendix A). After discussions about their project with the SAS program coordinator, each student's final learning contract was then signed by the three involved parties: (1) the host, (2) the student, and (3) the SAS program coordinator. The faculty supervisor reviewed all contracts for feasibility and logistical soundness. The program coordinator communicated with each host at least three times during the course of the summer to evaluate student progress on her/his project.

Reflection, or the act of describing actions, thoughts, and feelings about those actions, and linkage of these feelings to the community, is known to be the key to successful "learning" in service-learning projects (Merriam and Caffarella, 1999). Accordingly, time was set aside in the weekly mentoring meetings for reflection on the service-learning project, the research process, and on-farm experiences to ensure intellectual engagement for the Scholar's entire tenure in the program. After completion of their projects, students gave public oral presentations to the university community and invited host organizations.

Program Evaluation

Student feedback was collected in Y1 and Y2 by a third party through two separate assessments: (1) a focus group discussion and program evaluation (post-evaluation, Y1), and (2) pre- and post-evaluation through individual interviews (Y2). While objective-related content remained the same from Y1 to Y2, student feedback prompted minor changes in scheduling that more fully integrated research sample collection with farm visits. Slight changes in farms visited reflected a commitment to coordinate discussion topics with farm visits as described above. Pre- and post-program evaluations with a non-SAS student comparison group were added in Year 2. Two non-SAS students were used in this comparison group. Both students were summer employees in laboratories that had a similar research focus on sustainable agriculture practices and agroecology. Each student was hired to work with a specific graduate student on that grad student's field research but was also called upon to help other lab members as needed on a daily basis. Both non-SAS students spent more time working in the field than working in the laboratory. Field settings were either vegetable plots on university-owned research acreage, or natural areas and regional parks. Neither of the non-SAS students worked on an independent research or service-learning project.

In the second year of the program, all students were interviewed in the pre-evaluation individually in the first week of the program and again shortly after the last week of the program. The pre-evaluation questions focused on the student's background, familiarity with sustainable agriculture and research in general, and expectations about the program. The post-evaluation questions focused on students' perceptions and attitudes about the elements of the SAS program or their summer employment, sustainable agriculture and research as future career pathways, and the learning experiences within the SAS program or their summer employment. The second year post-evaluation was broader in scope than the first year post-evaluation, including first year questions; thus, only Year 2 protocol is presented (Table 1). All interviews were transcribed and coded using the qualitative software program ATLAS.ti (2004). An initial coding framework (Miles and Huberman, 1984) was developed for students' learning, attitudes and activities in the laboratory, farm/field, and service-learning environments. Additional codes were developed around outcomes as we engaged in the analyses. Codes were also developed during analysis for attributes of the students (background, career goals) in order to describe interactions with outcomes.

Results and Discussion

Participants in the program came from undergraduate programs in the College of Agriculture and Life Sciences at Cornell University (Table 2). Cohort 1 were all female, 3rd-year students, and each applied to the program because of an interest in agriculture or applied research as a future career pathway. Cohort 2 included one 1st-year male and two females: 1st-year and 3rd-year students. The 3rd-year student applied to the program because of an interest in organic agriculture as a future career pathway. The two 1st-year students applied to obtain an initial research experience. The non-SAS student comparison group was comprised of two summer employees in sustainable agriculture research groups who responded to a call for volunteers to participate in this study. Non-SAS Student 7 applied for summer work, specifically a plant-science-based lab, in order to explore this type of research as a future career pathway. Non SAS Student 8 applied for summer work in the lab to get an initial research experience.

Relationship between Sustainable Agriculture Research and Its Application

The three major learning environments were the laboratory, the farm visits/weekly meetings, and the environment of each student's service-learning project. Though

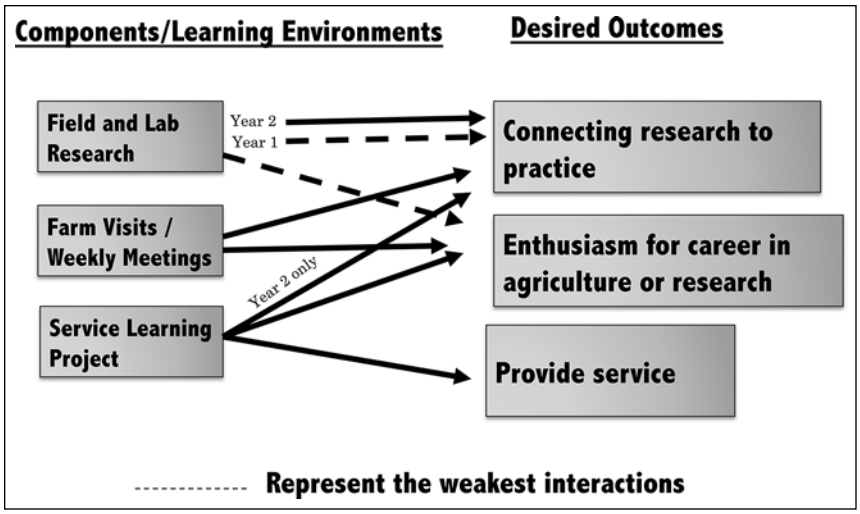

Fig. 1. Relationship between SAS program learning environments and program objectives. Results are shown for both cohorts unless indicated otherwise.

they reported learning about linkages between sustainable agriculture research and practice within all three domains, all students cited the farm-visits as the primary site of this learning, specifically through observations of sustainable agricultural practices related to their lab work (cover crops, nitrogen cycling) and interactions with farm personnel (Fig. 1).

S1: I really think that the farm visits are incredibly valuable…you learn a lot and it's that same sort of application of what you are doing in the lab to the real world and it really gives you meaning and significance. I think that's really important.

On-campus weekly meetings with professionals were less important learning sites than farm visits; however, students expressed appreciation for the interaction with research and extension personnel. All Y1 students suggested that becoming more involved in the research process might improve the experiences in the laboratory processing soil and plant samples. Accordingly, in the second year of the program, research sample collection was fully integrated with the farm visits. Students collected samples from a variety of locations on the farm after the farm practitioner gave them a tour. Students collected samples from fields shortly after hearing from the practitioner about the management of that field. Thus, students had a larger role in the research process, from sample collection through data analysis and a physical link between the two learning environments, the field, and the lab. This change helped the students to make strong associations between the laboratory work and sustainable agriculture practice in the field.

S5: I mean, it definitely did [make the lab work seem more meaningful] because we could see within the lab and in our work with different farms and the data we were collecting and analyzing, it really did help that. We could see how the information that was provided from our research was going to go back to the farms and what they were going to do with that and how they were going to make management choices through that for their farms.

In addition to observing and listening to farm practitioners, students reported that witnessing the origin of the samples (farm and field situation, type of cover crop) and participating in the sample collection helped them to understand aspects of their laboratory work and is implications.

S5 …that was definitely the best part. In terms of what we were learning, it's just so much more practical when you can go out there and you could actually see the differences in their soil…through talking with the farmer, we got to see their whole thought process in terms of what they were going to grow this season versus what they were going to grow next season, how they were going to rotate it, and what they were going to get out of it.

Furthermore, the quotes below demonstrate that the second cohort was able to describe the linkages between lab and field in more specific, research-based ways:

S4: I learned that as your fields are in better health you are not actually fixing as much nitrogen as when your field is in poor health, because there is already a lot (of nitrogen) in the ground. Things that would matter more I think would be the actual detailed numbers on that, how much you get, how much fixation you get compared with how much you already have in the field. That should help farmers decide whether or not they want legumes as cover crops.

S6: What we learned was the amount of nitrogen that legume plants would fix and supply to the soil for plants to grow in. So there were different kinds of legume plants that farmers could choose to use. And we were actually trying to figure out which ones were really good. I think vetch was an example. And when we went to the farm, there were farmers that were actually planting vetch to get the nitrogen benefits, so they were actually using it and it wasn't just like a scientific story.

Relationship between Student Service Projects and Agricultural Practice

Student service-learning hosts are listed in Table 3. Students in the first cohort reported that their service-learning project did not contribute to developing an understanding of the link between research and practice. Two of the three students in the first cohort chose to work together and with a host environment that was familiar to them, the university student farm. However, they chose herb gardening as their project, a theme not related directly to the focus of their laboratory research, as organic agriculture and soil nutrient cycling refers to the focus of the laboratory project. The third student chose a project that was also unrelated to laboratory goals

Table 1. Pre- and post-program evaluation protocols for SAS and Non-SAS students.

Pre-program evaluation:

1. Student background information

What year are you? What's your major? What courses have you taken in science, ecology, agriculture? What are your career goals? Describe your prior lab experience. Describe your prior agriculture experience. How did you develop your interest in this field?

2. Student expectations and preconceptions

What were your reasons for applying to this summer experience? What do you hope to gain from your experience this summer? What do you hope to learn? What is your understanding about what you will be doing in this program/lab employment this summer? Are you aware of the different components of the program? What do you expect to learn/how do you expect to benefit from (a) the lab work? (b) the service project? (SAS students only) (c) the farm visits/farm work? (d) invited speakers? (SAS students only) What services are you most interested in providing for your service project? (SAS students only)

Post-program evaluation:

1. Tell me what you did in the program/lab this summer

What equipment did you use, what techniques did you learn? What did you do on a daily basis? (What would a typical day look like?) What was the purpose of your work? In what ways did you benefit from this as a student, researcher? What did lab work teach you? How else did you benefit? What are some applications of the work or its findings?

2. Describe your service project (SAS students only)

What did you think you would learn in your project? Do you feel that you achieved your goals?

Did your service-learning project meet your expectations? What did the service project teach you? Do you feel that you provided a useful service to your hosting organization? Did your service-learning project provide you with any examples of how research is being applied in the field? (or how research could be applied?) Can you describe? What might we change for future service-learning experiences in the SAS program? In what other ways did you benefit from this?

3. Describe the farm visits (SAS students only)

In what ways did you benefit from this? What did the farm visits teach you? Help you better understand the application of the lab research findings to sustainable agriculture? How much did you interact with practitioners?

4. Other activities/invited speakers?

Were there any activities/speakers that helped you better understand the application of the lab research findings to organic soil fertility management and/or sustainable agriculture as a whole? Which ones and how were they meaningful?

Did you participate in any other lab- or research group-related activities? Did any of these help better understand the application of the research to the real world (of agriculture)? How/explain. (Non-SAS students only)

5. Interacting with lab members

How much did you interact with others in the lab? What were those interactions like? (a) PI, (b) Graduate students, post-docs, technicians? (c) Other undergrads? What did you learn from others about working in the lab? About being a student? About the process of research? Or research in general? About what graduate school might be like?

How much did you interact with park or farm personnel? (Non-SAS students only)

6. What are your career goals?

Have these changed as a result of participating in this program/lab employment this summer?
Did any of the activities shift your thinking about possible career options? If so, which?
Have you made any decisions about your academic career based on an experience you had, or knowledge gained, as part of the SAS program? Please describe.

7. Closing questions

SAS students:

How can the Sustainable Ag Scholars program better develop the link between the research you are doing day-to-day as part of your employment, and the larger field of organic soil fertility management, or sustainable agriculture as a whole? If you were designing the program, what would you include that would help scholars to better understand the lab/field research they were doing? Any other general comments about what worked and/or what didn't work?

Non-SAS students:

How can the summer lab experience be improved? What didn't work for you this summer? What support would you have appreciated? What would you change or add in order to make it more of a learning experience? Any other general comments about what worked and/or what didn't work?

(composting), in an unfamiliar host environment (cooperative extension). Conversely, the second cohort did report learning about the link between research and practice through their service projects. The second cohort's choices in service-learning project demonstrate how the nature of the service-learning project can contribute to developing understandings about the link between research and practice. Students 5 and 6 worked together to design a service-learning project that involved organic agricultural practices: preparing an organic berry garden and management plan at the same university farm that served as a host for the first cohort. Both of these students describe how the farm visits and laboratory work helped inform their independently designed service-learning project. Local farm practitioners shared their management plans and described the ways in which these plans were tai-

Table 2. Student home departments, prior coursework related to sustainable agriculture, and prior research experience.†

Student	Year in undergraduate program	Major	Prior sustainable agriculture coursework	Prior laboratory experience
1	3rd year	international agriculture	some	none
2	3rd year	environmental technology	some	none
3	3rd year	plant biology	some	some
4	2nd year	biological engineering	none	none
5	3rd year	natural resources	some	none
6	2nd year	engineering	none	none
7	3rd year	biology	none	ample
8	3rd year	biology and society	none	none

† "Sustainable agriculture" coursework here is defined as any course containing the words "agroecology," "sustainable agriculture," or "organic agriculture" in the course title. Students 7 and 8 were non-SAS program students.

lored to their specific situations and needs. Further, these students incorporated cover-cropping and nutrient amendment into their management plan based on what they were learning through their interactions with laboratory research. Student 4 was a research-focused student with little interest in sustainable agriculture as a focus of study or career path. This student chose a laboratory-based project answering a farmer question about soil nutrient management. While Student 4's project, piloting a new protocol and generating an analysis of data useful to lab members and to organic growers, violated our definition of service-learning ("meeting public needs"), his project provided him an opportunity to develop analytical research skills and balance the less interesting routine work with more rewarding pursuits.

Our data and discussions about the service-learning projects revealed a sense of ownership and accomplishment for all six SAS program participants, and for the five who conducted their service-learning outside the lab, a sense of satisfaction about providing a service or making some contribution to their community. The five students with community-based projects demonstrated their commitment to and enthusiasm for the service-learning component by volunteering far more of their personal time and making plans to extend the project into the academic year through independent study.

Viewing the varied experiences of all six students helped us understand how student's choices in service projects impact the link between sustainable agriculture research and practice. We attribute the strong Y2 link between service-learning and the program goal of "connecting research to practice" to student selection of service projects that were more related to lab research objectives (soil science and organic production) than in Y1. In Year 2 the service-learning projects were such that they helped students to integrate and apply concepts they were learning through the other two learning environments (farm visits/weekly discussions, and field/lab research), with one project being entirely lab-based. While projects in which students conduct lab-based research may be beneficial in creating focus, they also risk detracting from the desired well-rounded educational experience one would have if working with an organization external to the university. We conclude that the program coordinator has an important role in guiding students toward projects that are related to broad laboratory themes and topics, but that are not entirely laboratory and research-based. Such an approach would complement laboratory research questions while broadening students' worldview about sustainable agriculture research applications.

Table 3. Service-learning projects and host organizations.

Host	Project
Cornell University's Dilmun Hill Student-run Organic Farm and Experiential Learning Center	Year 1: Herb garden management and educational materials development
	Year 2: Growing, preparation, and uses for natural dyes
Ithaca Compost Education Program	Year 1: Developed compost system plan for Ithaca city school district
Ithaca Childrens' Garden	Year 2: Natural dye making workshop and curriculum development
Organic farm research/Cornell University	Year 2: Laboratory measurement of organic matter fractions from farm soils

Non-SAS Comparison Group

Though each non-SAS student clearly described how their graduate mentors explained the overarching goals of their research projects, the two students did not describe developing their own understandings about how the research projects they were working on connected to agricultural practices. They did not have opportunities to discuss practices with actual practitioners (farmers, parks personnel, ecologists). Student interviews revealed a lack of education about the goals of the research project in which they were involved.

S8: Our professor has many, many studies going on and most of the time we didn't know what we were doing, what it was for…We learned I guess about a few techniques but we didn't get to see any results of the studies so we don't know really know exactly which kind of organic farm practices were best. So I guess, yeah, we learned a few things but I wouldn't say a lot. I wouldn't say I'm very knowledgeable about organic farms after doing all that.

Interest in a Sustainable Agriculture-Related Career

Four students reported an increase in interest in sustainable agriculture as a career or area of future study (graduate school, further undergraduate research opportunities) as a result of participating in the SAS program. Two of these students reported an increased desire specifically to pursue sustainable agriculture research in their future career or studies as a result of their participation. Students demonstrated this interest in a variety of ways: enrolling in sustainable agriculture–related elective courses, continuing their tenure in the research laboratory into the following semester, and in discussing their long-term plans. Students' expressions about motivation and enthusiasm for the SAS program and for sustainable agriculture as a future direction emerged from their talk about the farm-visits and their specific service-learning projects. Discussions about farm visits centered on witnessing innovative practices, meeting interesting people, and discussing with them real farm management problems.

S2: I think I was definitely inspired by the summer… the summer stirred me to take more agricultural classes this semester and that further interested me into going into agriculture after graduation.

S1: I'm very intrigued by possibly going into production, working on a farm, and growing food. I'm really interested in food systems. I think that I'd like to at least for part of my life experience that end of food systems…I think the farm visits, like I said before, were definitely inspiring in that direction and sort of solidified my thoughts on it.

The four students who appeared most enthusiastic about the SAS program and stated increased interest (1) were 3rd-year students closing down the exploratory phase of their academic career and searching for a post-graduate pathway, and (2) had demonstrated interest in the field of sustainable agriculture through prior course work and/or extracurricular activities. It is important to note that these students claimed that their interest increased rather than waned. A critical goal of this pilot program was to increase student interest in sustainable agriculture as a career option or area of future study. By fostering and maintaining interests of talented students, such students are encouraged to make choices that move them further toward a career in sustainable agriculture. While none of these students is certain about their path, each is now seriously considering sustainable agriculture after a significant experience with it, whereas before it was merely an academic interest. A highlight for the 3rd- and 4th-year students was the discussion with the Career Services representative who taught students about available university resources to identify future agricultural employers post graduation. Both non-SAS students reported that they enjoyed their summer work experiences. However, neither spoke about being inspired or having a sense of ownership or accomplishment.

Other Benefits and Outcomes

In addition to student learning about the connections between sustainable agriculture research/practice and being motivated to pursue a career in sustainable agriculture, the comparison between SAS and non-SAS students highlights the importance to students of conducting independent intellectual work. The service-learning project allowed students to experience first-hand the challenges of working with unknown factors, different strategies for problem solving and compromising, and other constraints like time and resources. The more in-depth post-program interviews brought out some of the lessons students learned in the process of independent work: time management; setting, monitoring, and modifying realistic goals; seeking resources in the literature, on-line and in consulting experts; becoming self-reliant and learning through trial and error and looking for feedback. Non-SAS students reported that they learned primarily from observing and interacting with their graduate student mentors. Through their mentors (typically graduate students), these students described learning about the messiness of actual science practice such as coping with uncertainties, modifying plans and expectations based on data, and making the best of field conditions. By contrast, the SAS students were able to experience these important learning experiences for themselves, first-hand. While it is true that our observed outcomes could possibly be a result of the individuals involved rather than the program, all students who expressed interest in pursuing further studies/careers in sustainable agriculture attributed it in part to the program's activities. This study was a pilot and not designed to answer research questions related to program effectiveness.

Program Challenges and Areas for Further Development

Analysis of students' comments and recommendations for improvements to the program suggest a stronger effort is necessary to *develop links between sustainable agriculture and research from the laboratory side of the equation*. While students described various ways in which visiting farms and talking with practitioners made their lab work seem more relevant, there were few instances in which students described how the results of their lab work could be relevant to the farming community.

It is also critical to note that the SAS program operated using a high level of financial and personnel support. The project coordinator was hired to manage the program part-time, and an external grant was sought to provide funding for the students' service-learning hourly wages, field trip costs, and any costs related to their projects. While there was an initial concern that the loss of a work-day might impact overall lab activities, we found that students returned to the lab after their service-learning day generally inspired and ready to continue the daily research tasks. As much time needs to be dedicated to student recruitment, and organization of the program, we recommend that similar employee enhancement programs dedicate staff time (postdoctoral associate, technician, other hired staff) to program coordination and organization, as we did. We also recommend that requests be made for internal support of similar programs to sustain them beyond the length of an external grant. An internal university-level competitive granting process may serve to make similar programs a 'feather in the student's cap' and recruit the

best and brightest students to the program. Further, if a similar program was conducted in many related laboratories simultaneously, it can serve to encourage learning across laboratory/research group environments through student-to-student interactions. Such university-based programs can help to recruit students to the university by emphasizing opportunities for paid hands-on activities that truly emphasize student learning, a rare combination at any university or college.

While our program is a named, stand-alone program, its activities are designed to be modular and can be replicated as components when necessary. Visits by extension personnel, farmers, and career representatives can be easily integrated into already-existing weekly lab meetings that most research laboratories hold. Farm tours can also be integrated into sample collection that might be taking place for research purposes either on working farms, or even on university research plots. The scale of the program may be less important than the quality of the activities, the emphasis on student–employee education and post-graduation preparation, and the level of integration with research questions, and even theory.

Conclusions

In order to recruit talented students to pursue sustainable agriculture careers and learn about the research process, we designed an experiential learning pilot program for summer undergraduate employees. Our program involved students directly in on-farm and laboratory research, structured weekly meetings and farm tours to discuss sustainable agriculture research and career options, and a service-learning project. While not a research project, we found that our program was successful in sustaining already-existing student interest in sustainable agriculture and encouraging—usually more advanced—students to pursue sustainable agriculture as a field of study and/or a career option. Students lacking initial interest in sustainable agriculture were found not to be inspired to alter their field of study or career path as a result of the program. We conclude that research-based projects with larger sample sizes should be designed to test their impact on upper-level students who have expressed an interest in sustainable agriculture. Our observations suggest programs that engage summer research laboratory employees in activities outside the realm of standard employment can possibly encourage students to continue following their interest in sustainable agriculture in their final years of college and beyond. This can result in an increase in students enrolled in agricultural degree programs, and students prepared to enter agricultural professions.

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Appendix A. Service-Learning Contract: Sustainable Agriculture Scholars

Site

Host name (farm or organization)

Project supervisor (supervisor of student)

Address

Phone

Supervisor's email address

Student

Name

Mailing address

Phone

Email address

Faculty supervisor

Name

Phone

Email address

1. What are your roles and responsibilities while on your service project? List your duties, projects to be completed, etc.

2. Describe the supervision to be provided by the organization or farm. What kind of orientation, instruction, assistance, weekly meetings, consultation, mentorship, etc. will you receive and from whom?

3. What do you intend to learn (not DO, that is next!) through this experience? Be as specific as possible. Use phrases like "I will learn…I will gain an understanding of…etc."

4. Describe how your project will enable you to meet your learning objectives. These activities should be worked out with your supervisor or your host in the field. Use complete sentences and active voice: "I will perform…I will observe…I will produce…I will participate in…etc."

5. How will your project contribute to the mission and goals of the organization/farm?

I confirm that the student has completed the above listed activities during the course of the summer within our organization.

_____ Signature of supervisor

_____ Date

About the author…

Julie Grossman is an Assistant Professor in the Department of Soil Science at North Carolina State University specializing in organic cropping systems. Central to Julie's teaching toolbox are pedagogical strategies such as service-learning, which she uses to help her students learn to collectively address public needs while developing disciplinary competency and skills. Most recently, Julie began leading a new project integrating community gardens in low-income Raleigh neighborhoods with undergraduate soil science and nutrition courses. She also serves on the Steering Council of the Sustainable Agriculture Education Association (http://www.sustainableaged.org/), a new professional association championing innovative educational approaches for sustainable agriculture.