Teaching Methods

Increasing Student Awareness and Understanding of Food Security by Integrating a Service-learning Project into an Undergraduate Hydroponic Food Production Course

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SUMMARY. Food security is a growing global concern. To meet the needs of an ever-growing population, food production practices will need to evolve to maximize food quantity and quality. Controlled-environment food production has increased significantly in the United States over the past 5 years, and a component of that production includes hydroponic food crops. In an effort to better prepare a workforce with knowledge of hydroponic crop production, a new course was added to an existing greenhouse curriculum. A service-learning project was integrated in the course that allowed students to experience both growing crops hydroponically and volunteering at a local food bank with a free meal program. Self-assessment showed a significant increase in student confidence in understanding food security by the end of the course. There was also a significant knowledge gained in defining terminology, factors, and the impact of food security in a community. The three guided reflections students completed during the course identified four common themes relative to the course content and service-learning project including the following: community benefits, value of volunteering, local and global effects of food insecurity, and personal growth.

Food security on a global and local level is becoming increasingly discussed. The ability to meet food security and nutrition goals require food to be available, accessible, and in sufficient quantity and quality to meet the demand of an ever-growing population and is a critical issue (Food and Agriculture Organization of the United Nations, 2015). Also, a recent study shows poverty is increasing substantially in urban areas, with a majority (>56%) of impoverished now living in urban areas (Eigenbrod and Gruda,

2015). Urban agriculture can contribute to food security in these impoverished areas by improving availability and access to nutritionally dense foods (Badami and Ramankutty, 2015; Orsini et al., 2013). In addition to traditional food production methods in urban areas, food crops produced hydroponically in controlled environments can result in food that is accessible and of high quality (Premanandh, 2011).

The combined retail and wholesale value of food produced in a protected

culture, including greenhouses using hydroponic systems, has increased by \$243 million (44%) between 2009 and 2014 (U.S. Department of Agriculture, 2009, 2015). Hydroponic and controlled-environment food crop production provides opportunities to improve the quality and yield of the crop by manipulating environmental conditions and cultural practices (Krauss et al., 2006; McAvoy et al., 1989; Wu et al., 2004). In addition to predictable yields, quality produce, and value-added food crop production, hydroponic production systems can lead to increased food security. For example, hydroponic and controlled environment agriculture can improve year-round availability of and increase proximity to safe and nutritious produce (Premanandh, 2011). Depending on their design, hydroponic systems may incur significant capital investments; however, simplified hydroponic systems offer low-cost solutions that can increase the accessibility to this production method and the resulting produce (Izquierdo, 2007).

To support and manage this increase in hydroponic crop production, undergraduate greenhouse curricula should include education and training techniques in hydroponic production of fruit and vegetable crops. Shoulders et al. (2016) surveyed 110 four-year colleges and universities across the United States to determine the prevalence of hydroponic and greenhouse food crop production courses. They reported only 4 courses of the 84 courses related to greenhouse production focused on greenhouse food crop production. There is clearly a need for more curricula to include greenhouse food crop production.

Craver and Williams (2015) suggest hydroponic production modules could be developed and incorporated into existing greenhouse or fruit and vegetable production courses to further increase student knowledge and awareness of greenhouse food crop production practices. Greenhouse crop production courses primarily focus on the technical aspects of producing food crops in controlled environments. We believe that coupling the technical aspects of hydroponic crop production with engaging learning strategies such as hands-on laboratory exercises and service-learning projects

may create a richer learning experience for students.

Service-learning is a proven pedagogical method that connects classroom learning with community service and increases engagement and promotes deeper learning among students (Grossman et al., 2013; Waliczek and Zajicek, 2010). Garner (2011) reports that with this deeper understanding of content, students can more readily transfer their knowledge to the community via the service project. In addition to connecting curriculum content to a service project, service-learning requires student reflection. This combination of action and reflection empowers students by making them responsible to participate in a real world context, while providing them the skills and support to be effective (Rosenberg, 2000).

The curricular need for a hydroponic food production course at the Iowa State University created an opportunity to develop a new course with an extensive laboratory component to produce food crops hydroponically and to integrate an associated service-learning project. Our objective was to create a course that directly connected course content (the technical aspects of hydroponic crop production) to a service project that increased student understanding and awareness of food security issues in their community and globally.

Methodology

COURSE DESCRIPTION. HORT 331- Hydroponic Food Crop Production is a three-credit undergraduate course first offered in Fall 2014. The 15-week course includes two 50-min lectures and one 1-h and 50-min laboratory weekly. The prerequisite to enrolling in the course is HORT

221- Principles of Horticulture Science, AGRON 181- Introduction to Crop Science, or three credits in biological sciences. Most students enrolled in the course are majoring in Horticulture, with some from allied majors (i.e., Agronomy and Agriculture Education), and a few from unrelated majors (i.e., Electrical Engineering and Industrial Design).

The lecture content is divided into three sections. The first section introduces the history of hydroponic food crop production, the current state of controlled-environment agriculture, and the hydroponic systems most frequently used. The second section of lectures focuses on the principles of hydroponic food crop production, including water quality, mineral nutrition, light, temperature, carbon dioxide, and pest management. The final section features crop-specific lectures on growing tomato (*Solanum lycopersicum*), pepper (*Capsicum annuum*), cucumber (*Cucumis sativus*), lettuce (*Lactuca sativa*), culinary herbs, and strawberry (*Fragaria xananassa*).

The laboratories focus on producing hydroponic food crops using nutrient-film technique (NFT) systems, deep-flow technique (DFT) systems, double rows of coconut slabs, and double rows of Dutch buckets (Currey, 2016; Jones, 2005; Resh, 2013). Lettuce was grown in both NFT and DFT systems and herbs were grown in the NFT systems. Tomato and cucumber were each grown in Dutch buckets and coconut slabs.

FOOD SECURITY SERVICE-LEARNING PROJECT. Food security was incorporated into different aspects of the course, including lecture content, laboratory activities, and service-learning outside of scheduled class time. There were three 50-min lecture periods focused on food security and the service-learning project. The first lecture included an introduction to food security and a presentation from the community partner on the background and function of the organization. About halfway through the semester, a presentation was delivered that discussed fundamental concepts related to food security, including factors that affect food security, what populations are most vulnerable to food security, etc.

The service-learning community partner was Food at First, a local,

nonprofit meal program and food bank. When lettuce, herbs, tomatoes, and cucumbers matured, students harvested these crops, and packaged them for delivery and distribution to the food bank, and for use in the free meal program. Crops were harvested weekly as part of laboratory activities. Because the delivery would frequently occur after the laboratory period had concluded, participation in the delivery process was optional for students.

In addition, students participated in volunteer activities at the food bank during a period in the middle of semester. Volunteer activities included one of the following three different experiences: 1) assisting with food distributions at the food bank; 2) assisting with the preparation of meals for the free meal program; or 3) assisting with serving and cleaning up for the free meal program. When possible, the crops the students produced were incorporated into the meals prepared for the free meal program. Students were required to participate in one volunteer shift in 2014, whereas in 2015 students were asked to participate in two volunteer shifts. Students chose which type of volunteer experience(s) they wanted to participate in.

ASSESSMENT. To understand the impact of the service-learning project on student understanding and awareness of food security, we used a combination of quantitative and qualitative evaluation methods. At the second class meeting of the semester, students were provided with an Institutional Review Board (IRB)-approved (Iowa State University IRB no. 14-382) pre-self-assessment. The self-assessment contained five statements with Likert scale (Likert, 1932) responses (1 = strongly disagree, 5 = strongly agree) designed to quantify their confidence in understanding food security (Table 1). After the self-assessment was completed, students were provided with an 11-question IRB-approved multiple-choice pre-quiz, containing questions on terminology definitions, factors contributing and related to food security, and the impact of food security. During the final class meeting of the semester, students completed the same self-assessment followed by the same quiz, as they did in the beginning of the semester.

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Table 1. Pre- and postsemester self-assessments related to food security (1 to 5 scale) from students enrolled in a hydroponic food crop production course in 2014 ($n = 25$) and 2015 ($n = 24$) that included a service-learning component at a local food bank and meal program. Data were analyzed using a t test with an $\alpha = 0.05$ and the significance (Sig.) is reported.

Question	2014			2015		
	Pre	Post	Sig.	Pre	Post	Sig.
I can define the term “food security.”	3.5 ^z	4.6	***	3.9	4.8	***
I can describe how food security impacts individuals, families, and communities.	3.3	4.4	***	3.8	4.8	***
I can list the economic and societal factors that contribute to food security.	3.1	4.4	***	3.6	4.7	***
I know what health issues are frequently related to food security.	3.4	4.3	***	3.5	4.8	***
I can list, and define, the four pillars of food security.	2.2	3.5	***	1.9	4.8	***

^z1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, 5 = strongly agree.

***indicates significant at $P \leq 0.001$.

In addition to quantitative measurements we also assessed food security qualitatively through guided reflections. Students submitted three reflections throughout the semester focusing on three different themes. Before assigning the first reflection, the instructor provided the explanation that reflections were not simply a description of events but were intended to be personal and emotional responses to information and experiences. The first reflection was completed at the beginning of the semester following the introductory lecture on food security and the introduction of the service-learning project, but before any laboratory or volunteer activities had begun; students were prompted to focus on their thoughts on food security and impression of the proposed service project. The second reflection was completed in the middle of the semester following completion of their volunteer experiences, and students were prompted to focus on their time and experiences at the food bank, meal program or both. The final reflection was completed at the end of the semester following the final lecture dedicated to food security and wrap-up of the service-learning project, and students were prompted to focus on the overall experience, connecting lecture content and laboratory activities with the service-learning experience and food security concepts.

DATA ANALYSES. There were 25 student respondents in 2014 and 24 student respondents in 2015. Data from the self-assessments and quizzes were analyzed using a t test (SPSS

21.0; IBM Corp., Armonk, NY). Data for the quiz percentages were arc-signed transformed for analyses and back-transformed for presentation (Little and Hill, 1978).

In this study, we used a combination of in vivo coding and structural coding approaches to identify codes based on words and phrases used by students in their reflections to identify themes across the data (Leavy, 2017; Saldana, 2009). Data gathered from the three guided reflection prompts were pooled across years for each reflection. The pooled data were uploaded into a qualitative data analysis software [NVivo; QSR International (Americas), Burlington, MA]. Data (i.e., the reflection text) were labeled independently by two social science researchers with qualitative codes developed using an iterative process of identifying, recording, organizing, refining, and synthesizing narrative data to understand patterns and themes in responses (Creswell, 2014; Saldana, 2009). Once all data were coded, thematic analysis was used to synthesize the codes into common themes. Once themes were identified, the frequencies and percentages of themes within each reflection were quantified using descriptive statistical analyses (NVivo).

Results and discussion

SELF-ASSESSMENT AND QUIZ. In both 2014 and 2015, student post-semester self-assessment scores increased compared with pre-semester self-assessment scores for every statement (Table 1). The percentage of

correct quiz answers also increased from the pre-semester quiz to the postsemester quiz by 59% to 75% and 55% to 81% in 2014 and 2015, respectively. When the self-reported increase in knowledge and performance on quizzes are taken together, student understanding of food security increased over the course of the semester in both years.

REFLECTIONS. In both 2014 and 2015, most students responded enthusiastically about their experience in the class and volunteering with the Food at First program via the three reflections. The students' first reflection focused on their impressions of the service-learning project and its purpose. The students' responses included several key elements, including the following: 1) the community benefits of the program (74.5% of students included this theme in their reflection; 2) their thoughts on local and global food waste in society (19.6%); 3) their impressions of volunteering (17.6%); and 4) the quality of food available to those in need (13.7%).

In the second reflection students were asked to include a description and analysis of their volunteer experience and several themes were highlighted throughout the students' responses. There were no common themes in the description of their volunteer experience because students did a variety of jobs via their participation with Food at First. The consensus overall was that it was a humbling experience and many were surprised at the atmosphere and availability of food at the food bank and meal service. The themes drawn from the analysis included the following: 1) the community benefits of the program (89.8% of students included this theme in their reflection); 2) their positive experiences when interacting with people at Food at First (28.6%); and 3) the students' reflections on local and global poverty (16.3%).

The third reflection evaluated the impact of the service-learning experience and its connection to class content. The themes for the students' reflections centered on 1) their experience volunteering (76.6% of students included this theme in their reflection); 2) their ability to provide for those in need (48.9%); and 3) the community benefits of their service (34%).

Although each reflection was based on a specific writing prompt, reflections were also pooled and evaluated to find broader themes across reflections. There were four common themes that emerged across all three of the reflections: 1) community benefits, 2) value of volunteering, 3) local and global effects, and 4) personal growth.

Students thoroughly described their appraisal of how the Food at First program benefitted the community. The “no documentation” procedure of Food at First not requiring their clientele to provide evidence of their need for food was one example consistently mentioned as an important part of the program because students believed that this policy helps create a positive, “no judgment” atmosphere. Student descriptions about the benefits of volunteering were linked to the benefits they saw to the community (e.g., free healthy meals), to the Food at First program (e.g., volunteerism), and to themselves as a result of volunteering (e.g., personal gratification).

Students also emphasized the local and global issues across their reflections. For example, students reflected on personal and business waste as well as the existence of local and global poverty. Students described personal growth as a result of the class and their volunteer experiences. Many students described the class as a great benefit to themselves and others. “It is unique to have a class that goes beyond your personal education and actually benefits the community at large. I hope this class continues to require the service component so that other students can become aware of not only the need, but possible solutions.” Through the service-learning project, students indicated they have become more aware of local issues, personal responsibility, and how they can positively contribute to society.

Overall, knowing where the produce was going was an important aspect of the program and helped students connect the service-learning experience to the course content. One student summarized the rewards of the experience by saying, “Growing plants for people who need it is a great gratifying feeling, but seeing, meeting and interacting with the people who benefit from your hard work is rewarding.”

COURSE IMPROVEMENTS. Despite the positive experiences students mentioned, many acknowledged opportunities to improve the course and volunteer experience (38.3% of students included this theme in a reflection). Many students expressed a desire to provide Food at First with a greater variety of crops. Students also noted that requiring multiple shifts would be beneficial and that each shift should be a different experience to provide a better view of the Food at First program.

A number of students also expressed a desire to be able to distribute the produce directly to the Food at First clients as a means to more fully connect with their service, laboratory, and class experiences. Students who did get to serve the food described very positive experiences. For example, students who volunteered in a food-serving role indicated they were able to explain to other volunteers and attendees how hydroponics work and how they grew the food.

Conclusions

The service-learning component of the course was successful in directly connecting course content to increased student understanding and awareness of food security issues in their community. The self-assessment, quizzes, and reflections show both knowledge gains relative to course content and personal growth in this hydroponic food production course. Having a well-defined service-learning project with clear expectations and a strong working relationship between the community partner and faculty member helped ensure all parties involved had a beneficial experience.

This study supports the construct that service-learning is a valuable experience for students and communities. The service-learning component added a positive dimension that allowed students to learn more about themselves and the world around them. One student summarized their volunteer experience this way, “It made me feel especially proud that I had a part in not only growing the crop but serving it as well. I would tell everyone who wanted the salad where it came from and how it was produced. It was as if I had ownership in it and was enthusiastically

explaining how hydroponics worked. It didn’t take long before a few of them started calling me ‘lettuce man’. It was kind of cool because it was a term of endearment and it made me feel recognized and part of something way bigger than a free meal.” Based on student comments we plan to continue the service-learning project in this course and will explore ways to further student engagement, learning, and community impact.

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