2017

Service Learning as Inquiry in an Undergraduate Science Course

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INQUIRY & INVESTIGATION

Service Learning as Inquiry in an Undergraduate Science Course

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Abstract

To engage students in applying scientific process skills to real-world issues, we implemented a service-learning project model in our undergraduate introductory biology course for science majors. This model illustrates how we integrate inquiry inside and outside of the classroom through four steps: service, learning, classroom, and community. Out-of-class activities engaged students in serving the community (Service step) while deepening their learning experience beyond what they would learn in a classroom (Learning step). To connect the service-learning project with scientific process skills, students were asked to identify problems that our community partners were trying to solve, identify proposed solutions, and design ways to evaluate those solutions (Classroom step). Additionally, students connected their service-learning topic with core concepts in Biology. After their service, students used metrics to analyze their impact. Students then synthesized the connection between their service, learning, and classroom projects by presenting their findings to the scientific and lay communities through a poster session (Community step). Here we provide details of the model, recommendations, and examples for others to execute an inquiry-based service-learning project.

Key Words: *service leaning; undergraduate science; inquiry.*

○ Introduction

Our project began with a student's lament, "I don't understand why I need to learn biology."

The idea that this Introductory Biology student could not connect his dream of designing third-world water systems to the scientific content and skills that he was learning in the classroom struck a chord with one of the authors (KMB). To address this disconnect, we instituted a service learning project within the biology class. The purpose of this article is to share our service learning model and its associated examples.

A central component of service learning, a high-impact activity, is for the instructor to help students reflectively make connections between the course concepts and real-world experiences, deepening the quality of their learning (Kuh, 2008; Dewey, 1938). It is a growing national trend, with 40 percent of full-time, first-year students taking a course that involved a community-based project, and 68 percent of universities expanding the emphasis on service learning (NSSE, 2011). Unfortunately, perceptions that service learning lacks rigor and takes time have hindered the emphasis of service learning in the sciences compared to the liberal arts and social sciences (Sherman & MacDonald, 2009; Brubaker & Ostroff, 2000).

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We have developed a replicable, four-step, inquiry-based service learning model (Figure 1) for an honors introductory biology course for science majors. Importantly, the model can be modified for other science courses. It contains inquiry-based, active learning components and contexts designed to nurture students' sense of belonging to both science and civic communities. In addition, its collaborative approach offers students opportunities to (1) socially construct and apply scientific knowledge to real-world problems, (2) envision diverse science-based careers, and (3) benefit their civic community. These components have been shown to increase student persistence in Science, Technology, Engineering, and Math (STEM), and improve critical thinking (Graham et al., 2013; Eyler & Giles, 1999; Brownell & Swaner, 2010). Our design helps students meet Vision and Change (V&C) core competencies (AAAS, 2011) and Next Generation Science Standards (NGSS, 2013). This paper elaborates the details of our service learning project model, illustrating how we integrated inquiry inside and outside of the classroom.

The American Biology Teacher, Vol. 79, No 5, pages. 393–400, ISSN 0002-7685, electronic ISSN 1938-4211. DOI: https://doi.org/10.1525/abt.2017.79.5.393.

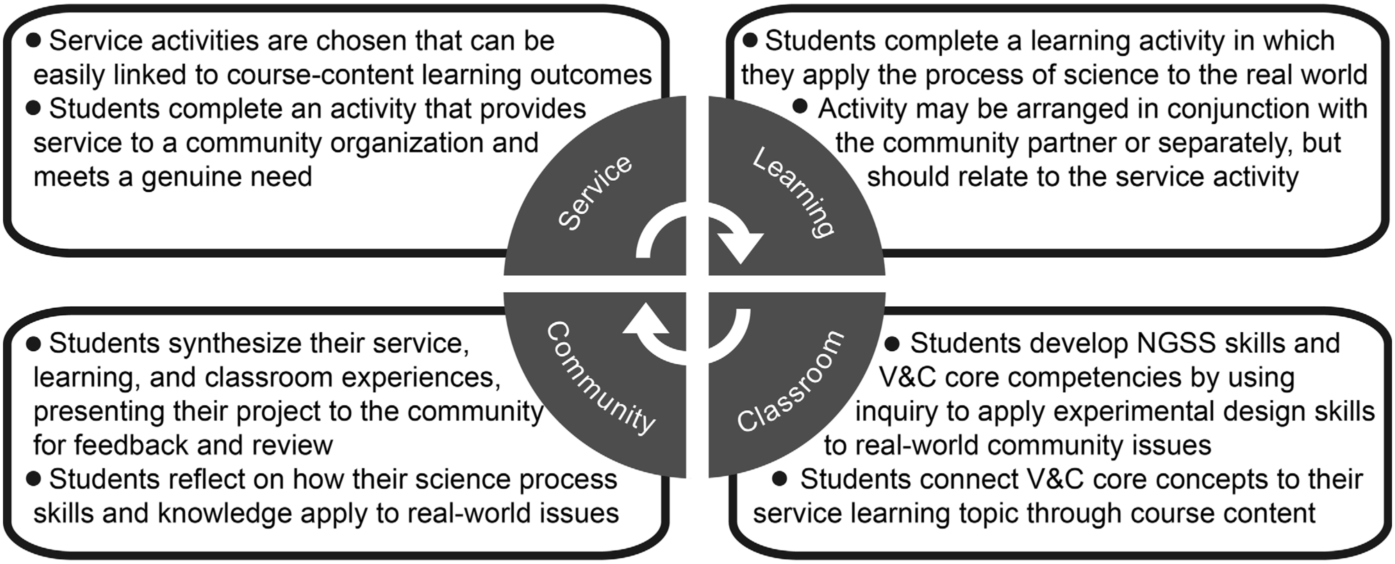

Figure 1. The four steps of the model of inquiry-based service learning are described in each quadrant. Connections to NGSS skills and V&C core competencies and core concepts are provided where possible.

○ Service Learning as Inquiry Model

We incorporated the scientific practice of inquiry (as defined by National Research Council, 1996) into service learning to help students apply scientific approaches and concepts to real-world problems. We used backward design (Wiggins & McTighe, 2011) to develop learning outcomes for the service learning project and to incorporate service learning into existing course learning outcomes. We then chose community partners whose projects could be easily linked to those outcomes. To connect science to the real world (Figure 1), students participated in an external service activity (*Service*), and a related, external learning activity (*Learning*). In *Classroom*, students completed activities that connected the coursework to their service learning project and introduced an inquiry approach as a scientific process. This step aligns with the V&C core competency "Apply the process of science" (AAAS, 2011) and NGSS skills "Asking questions and planning investigations" (NGSS, 2013). During a one-semester course, there is not enough time for students to carry out their planned experiments; however, they are introduced to evaluating evidence and using quantitative reasoning as they analyze the efficacy of their impact in the *Community* step. This process helps them move from a qualitative, anecdotal way of analyzing impact, to quantitative, measurable impact. In *Community*, students synthesized course content and solving of community problems with a capstone presentation to the academic and civic communities. This step aligns with V&C core competencies "Communicate and collaborate with other disciplines" and "Understand the relationship between science and society" (AAAS, 2011) as well as NGSS skills "Obtaining, evaluating, and communicating information" (NGSS, 2013). Consequently, students continue to apply the process of science to real-world community issues beyond their course, thus continuing the cycle of service learning to address civic problems. Modifiable materials and tips are available through this QR code (Figure 2).

Figure 2. QR code for https://osu.box.com/ServiceLearningCLSE.

○ The Model: Service and Learning Steps

Service and *Learning* (Figure 1) jointly focus on student engagement in activities that benefit the community through an extracurricular learning experience. The two separate steps emphasize that service and learning are equally important; this is not simply a community service activity.

Establish Learning Outcomes

We recommend metacognitive learning outcomes in which students reflect on connections between lecture material and community service. Our course learning outcomes focused on molecular and cell biology core concepts; our project learning outcomes focused on the connection between science and the real world (Table 1).

Engage Community Partners

Sustainability requires a balance of efforts. To build a trusting collaboration, community-identified needs must drive the service

Table 1. Example Learning Outcomes.

	Students will...
General Education	• Provide examples of the inter-dependence of scientific and technological developments. • Discuss social and philosophical implications of scientific discoveries, and understand the potential of science and technology to address problems of the contemporary world.
Project Specific	• Connect classroom lecture material to community projects / service. • Value evidence and understand how scientific process skills can be applied to everyday problems as well as larger contemporary societal issues. • Develop an awareness of science as a human endeavor. • Identify community needs and how individual, class, and university could help address those needs. • Recognize the social consequences of disparity between research funding and costs, differential disease demographics, and students' ability to impact those disparities. • Support the community partner by proposing community events that raise public awareness or by proposing a fundraising event.

Table 2. Ideas for Service Learning Projects.

	Students could serve by . . .	Students could learn by . . .
Community garden	Planting, cataloging, weeding	• Discussing with a master gardener how to solve agricultural issues • Constructing arguments for and against genetically modified organisms using researched evidence • Comparing and contrasting the biological and economic implications of organic vs. non-organic farming
Local science museum	Creating activity cart or hands-on experience for visitors	• Collaborating with museum staff to identify a topic of interest and research that topic • Proposing an activity cart topic to museum staff and/or creating the cart • Communicating with visitors and discussing the underlying science behind the activity cart
K-12 schools	Tutoring for after-school science program, mentoring science fair projects	• Preparing materials for the study sessions that encourage critical thinking • Helping students design science fair projects to ensure younger students can reach an evidence-based conclusion • Judging science fair projects to practice communicating science and evaluating scientific claims
Local health fundraisers	Helping with athletic events. working with national organizations like Susan G. Komen Race for the Cure or Jingle Bell Run for Arthritis	• Visiting a research lab that studies the topic and discussing open questions in the field and current approaches to problem solving • Meeting with patients affected by the topic to hear their personal stories, and considering the ability of science and technology to address societal problems

portion of the project—whether this is simply a need for bodies or for scientific expertise. Training and mentoring the students should not place a significant burden on the community partner (Clayton et al., 2013). Employment of existing networks facilitates identification of community partners who have: a genuine need, interest in working with college students, enthusiasm about contributing to student learning, and willingness to visit the classroom and attend the capstone session. Learning activities should extend the connections between course concepts and the service projects. Table 2 lists some ideas for service learning projects; Figure 3 shows the three community organizations with whom we partnered.

Clarify Policies, Expectations & Practices

Ideally, representatives from the community partners visit the classroom to help students choose a project and clarify expectations: what to wear, how to speak to the partner's constituents, whether photographs are permitted, and how to perform the various duties (see

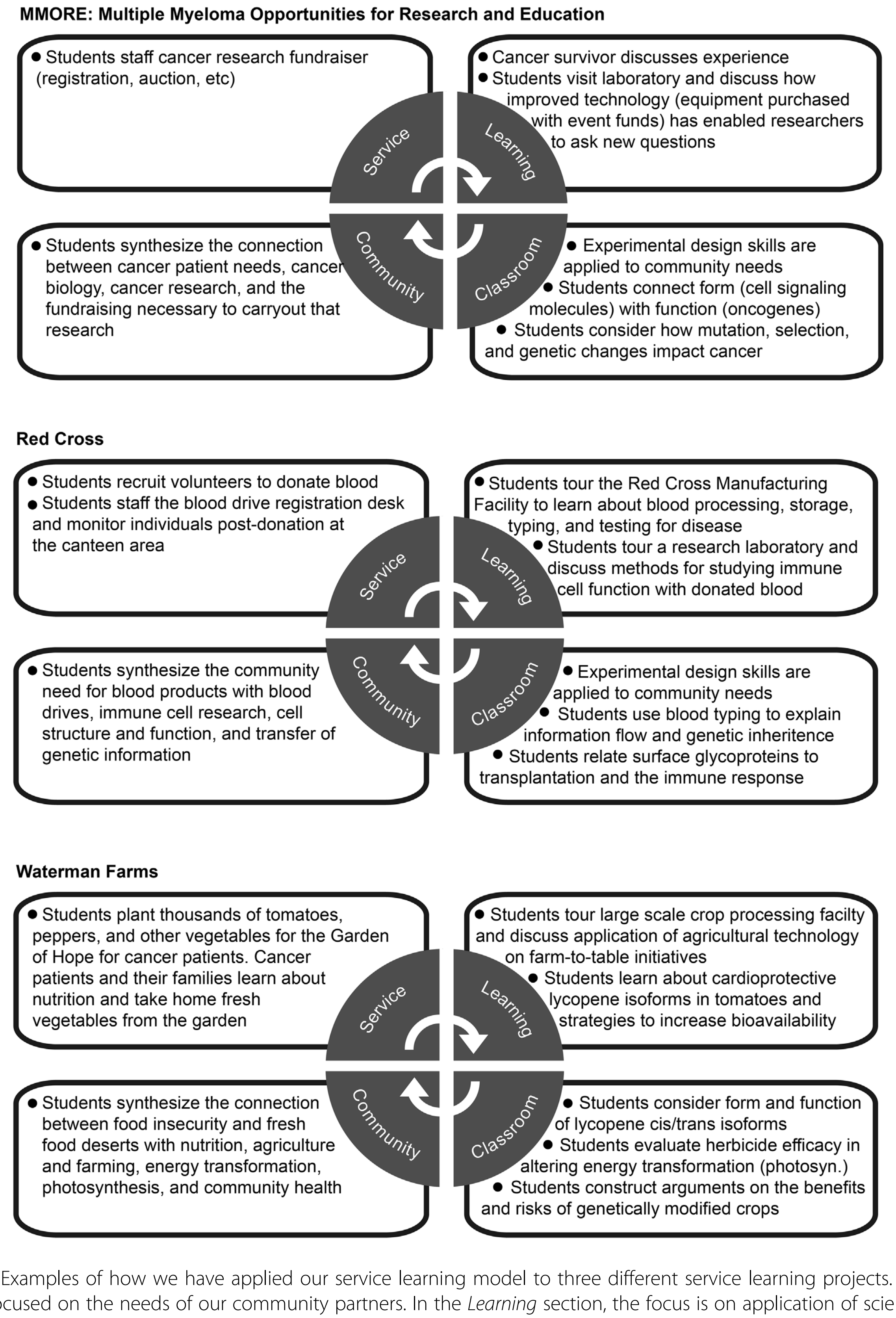

Figure 3. Examples of how we have applied our service learning model to three different service learning projects. The *Service* section is focused on the needs of our community partners. In the *Learning* section, the focus is on application of science to real-world problems and to understand the relationship between science and society (V&C core competency, AAAS, 2011). Ideally, students also practice—or are exposed to—scientific process skills. During the *Classroom* step, students practice the scientific process of asking questions, planning investigations, analyzing and interpreting data, and constructing explanations (NGSS, 2013; V&C core competencies, AAAS, 2011). Students also connect core biological concepts (as defined by V&C core concepts, AAAS, 2011) to their service project topic. Finally, in the *Community* step, students synthesize the connections they have made and communicate that information to peers, faculty, and the community (NGSS, 2013; V&C core competencies, AAAS, 2011).

supplemental course materials for sample community partner handout). We instructed our students that they would spend 4–8 hours outside of class participating in service and learning activities and two additional hours on the capstone project.

Fuel Student Enthusiasm

Student enthusiasm (Table 3) increases the success of this project. Pre-service discussions and post-service reflections help students recognize the importance of their contribution to the community and increases its value. Our students ranked their preferences for community partner (Figure 3), which increased student buy-in and excitement for the project. To limit student frustration, we: (1) introduced the project the first week of class, (2) repeatedly connected coursework with each activity, and (3) integrated reflections and post-service discussions. Students increased their comfort level by asking questions during community partner classroom visits. Additionally, we told students that they would learn more than just science with these experiences – some of our students have developed stronger career directions and goals after participating in these activities. When instructors participate in the activity, they serve as role models for integrating science into the community and build stronger relationships with students (Eyler & Giles, 1999). Former students may serve as peer mentors, providing effective role modeling and enhancing performance, retention and student satisfaction (Snowden & Hardy, 2012).

Putting all of this information for the *Service* and *Learning* steps together, we will briefly outline one of our projects. We partnered with the organization Multiple Myeloma Opportunities for Research and Education (MMORE) in which students staffed the organization's annual fundraising gala for the *Service* step (Figure 3). Part of the *Learning* step occurred simultaneously, as students listened to guest speakers regarding the current state of research and treatment for multiple myeloma. In a second, external *Learning* step, students toured a multiple myeloma research laboratory, discussed how equipment purchased with MMORE funds was used to further research, and met with a multiple myeloma survivor to discuss his experience with this disease. Amazingly, students—inspired to extend their civic engagement following this service learning experience—formed a new student club for multiple myeloma, a significant, but unexpected benefit for both students and the community partner. The *Service* and *Learning* steps from two other projects, Red Cross and Waterman Farms, are explained in Figure 3.

Table 3. Nurturing student enthusiasm.

Be transparent and discuss the rationale behind the project at the beginning and again as each component is implemented.
Allow students to choose the service activity.
Instructors and TAs participate in the project.
Choose peer mentors each semester to provide continuity to the new student cohort the following semester.
Provide opportunities to reflect on the importance of the work to the community and to the student.

○ The Model: Classroom Step

Classroom focuses on how students spend time during class; this can include both lecture and laboratory time. Because the model is managed from within the classroom, instructors should choose activities that support it. By developing course material strongly aligned with the project learning goals, instructors will ensure meaningful connections between coursework and the external project (Figure 1). Students should learn the difference between community service and service learning to help them make connections between the classroom and their service learning project. Most importantly, students must learn how to apply the scientific process skills to real-world community issues—a unique aspect of this project. The advantage of this approach is that students practice designing properly controlled experiments on topics that are more easily understandable and relatable than a traditional wet lab experiment. Discussing the "messiness" of designing real-world experiments can be eye-opening for students. Also, students should begin to consider the benefits to the community partner and to themselves that may result from their work.

To compare *service learning* with *community service*, students read the *New York Times* article, "Does Service Learning Really Help?" (Strom, 2009), and answered questions in preparation for an in-class discussion comparing community service and service learning. Additionally, students reflected on thoughts, actions, and behaviors that would ensure a successful project. In the "Mission Possible" assignment, students researched their service organization's website and considered ways their service would be helping its mission. In the "Real World Science Experimental Design" assignment, students made observations (personal experience, literature review, or feedback from the community partner) and formulated a question to address a community need. Using the scientific process, students proposed a solution based on that need, and made predictions regarding the outcome. Students next designed a test to evaluate their solution, discussed the type of analysis used to measure their results, and considered potential conclusions based on the significance and limitations of those results. An example is shown in Figure 4. For each part, students gave and received peer feedback, which has been shown to improve writing (Cho & Cho, 2011) and give students a better understanding of the assignment expectations (Hanrahan & Isaacs, 2001). Finally, students made revisions based on peer and instructor feedback and submitted one cohesive product. For a one-semester course, it is beyond the scope of the project for students to actually carry out their proposed experiments. The key issue here is for students to recognize that they can apply scientific process and analytical skills to solve real-world problems. This assignment aligns with NGSS skills, "Asking questions and planning investigations" (NGSS, 2013) as well as V&C competencies, "Apply the Process of Science," "Ability to tap into the Interdisciplinary nature of science," and "Ability to understand the relationship between science and society" (AAAS, 2011).

○ The Model: Community Step

In *Community*, students complete activities that underscore connections between classroom concepts and real-life application. Students synthesize their *Service*, *Learning*, and *Classroom* experiences in a final capstone project, communicating their contribution to the community. This

Observation: There are two major fundraisers that benefit cancer research on the OSU campus. Buckeyethon (an all-night dance-a-thon) is the largest student philanthropic event (>3,500 students) that raised $608,623 in 2013 for Nationwide Children's Hematology/Oncology unit. Pelotonia is bike ride that raises money for cancer research at OSU. The Team Buckeye student peloton consisted of 334 students in 2012 and raised $268,785.

Question: How can we increase student participation in Pelotonia to the equivalent of Buckeyethon?

Hypothesis: Students are not participating in Pelotonia because they are not aware of the event.

Prediction: Advertising Pelotonia during Orientation Week for incoming freshman would increase student awareness and lead to increased student participation in Pelotonia.

Experimental Design

1. Collect data on two groups of students:
   a. students that were exposed to advertising during orientation week
   b. those that were not exposed to advertising during orientation week.
2. Have both groups complete post-orientation week survey to determine how many freshman are aware of the event in each group and how likely they are to participate in Pelotonia.

Analysis

Compare total number of students in the four groups.

Category	# students
1. Exposed to advertising; Aware of Pelotonia; Pelotonia participant	
2. Not exposed to advertising; Aware of Pelotonia; Pelotonia participant	
3. Exposed to advertising; Not aware of Pelotonia; Pelotonia participant	
4. Not exposed to advertising; Not aware of Pelotonia; Pelotonia participant	
5. Exposed to advertising; Aware of Pelotonia; Non Pelotonia participant	
6. Not exposed to advertising; Aware of Pelotonia; Non Pelotonia participant	
7. Exposed to advertising; Not aware of Pelotonia; Non Pelotonia participant	
8. Not exposed to advertising; Not aware of Pelotonia; Non Pelotonia participant	

Conclusion

If the number of students in category 1 is greater than the number in category 8, then advertising was effective. If the number of students in category 1 is not greater than the number in category 8, then advertising was ineffective.

Limitations

1. Students may be exposed to other means of advertising than during orientation week.
2. The two groups of students may not be randomly distributed. In a study like this, it is important at the start that the groups of students (before the advertising) would be equally likely to participate or not participate in Pelotonia. Students who attend orientation events may be more likely to participate in extra-curricular events, but because we cannot ethically tell students they can or cannot participate in orientation, we cannot control for this issue.
3. We are assuming that advertising will lead to awareness.

Figure 4. Sample assignment for the Real World Science Experimental Design. Students practice applying scientific processes to real-world problems using the scientific method.

project should provide a unique opportunity for (1) students to practice communicating with the scientific and lay communities, (2) students to transition to a more expert role with a more sophisticated level of contribution, and (3) the community partner to benefit from hearing student scientific analysis of how to address real-world issues. During this process, students appreciate the relevance of their science learning and develop metacognitive skills. The capstone project allows students to take pride in their contributions and develop a sense of belonging to their academic and civic communities.

In our version of the model, students analyzed the metrics of their service activity (e.g., dollars raised, number of donations, number of projects funded, amount and diversity of blood types collected, number and diversity of plants planted, etc.) and drew conclusions about its efficacy. To be clear, we do not want students to think of this step as results of an experiment. Rather, we want them to move from using qualitative, anecdotal rationalization to quantitative reasoning (aligned to V&C, AAAS, 2011, and NGSS, 2013) to support an argument regarding the efficacy of their impact. Students presented a poster evaluating their experience to peers, faculty, and the community at a formal symposium, allowing them the chance to practice obtaining, evaluating, and communicating information (NGSS, 2013). In addition, students elaborated upon specific connections between classroom biology topics and their service activity, demonstrating their ability to understand the relationship between science and society (V&C, AAAS, 2011). Finally, students brainstormed ideas that would enable them to further help the community partner as an individual, as a class, and as a university. Our MMORE community partner was thrilled with the student-proposed creation of a campus club engaging college students, a demographic they had not previously recruited. As a final activity, students

Table 4. Student reflections on the Service Learning Project in response to the prompt, "Please explain what made this activity beneficial as part of the service learning project."

"The service component provided me with . . . an opportunity to connect classroom activities to the real world and real issues that exist."
"I have never donated blood, nor have I ever volunteered at a blood drive, but I learned . . . how complex and specific the blood donation and processing system is, which completely replaced my general idea of blood being donated then stored for use in hospitals."
"It was interesting to see the actual applications of what we were learning in class."
"It was interactive; human-human interactions always spark my curiosity (and subsequently, learning)."

Table 5. Assessment of Student Learning.

Direct Assessment
• Rubric analysis of Mission Possible and Real World Science Experimental Design Activities
• Rubric analysis of Capstone presentation
Indirect Assessment
• Attitudinal surveys
• Qualitative analysis of student reflections on the importance of the work to the community and to the student
• Student Assessment of Learning Gains (SALG; Seymour et al., 2000)

completed metacognitive reflections of their service learning projects and how they could be improved in the future.

○ Recommendations for Assessment of the Model

The purpose of this paper is to provide resources and a framework for others to apply this model in their classrooms, and this application will differ according to institutional and community contexts. It is key to identify the strengths and weaknesses of that implementation in the institutional contexts, whether those characteristics are being studied to broaden our understanding of the service learning model or to determine the success of the program. For example, we are in the process of completing an Institutional Review Board (IRB)-approved study measuring student learning gains, motivations, and scientific literacy associated with the model. These data will be reported in a separate article. In addition, we have evaluated the program regarding student attitudes associated with the service learning project (see Table 4), since student perception is an important consideration for project implementation. Finally, we have provided recommendations for how to assess student learning (Table 5) and community partner benefits (Table 6), which were two crucial components of our vision of successful implementation of the model.

Table 6. Assessment of Community Partner Benefit.

Direct Assessment
• Number of volunteers
• Number of tasks completed
• New ideas stemming from student involvement
Indirect Assessment
• Qualitative analysis of student awareness of partner mission
• Attitudinal surveys
• Content analysis of emails

In conclusion, we hope this inquiry-based model provides a mechanism for more STEM faculty to incorporate service learning into their courses as a high-impact activity. Additionally, we hope this experience encourages students to continue to be engaged in civic issues and further apply the process of science to community problems beyond their time as a student.

○ Acknowledgments

We thank instructors Drs. Richard Swenson and Steven Justiniano for supporting this project. Thanks to Teaching Assistants Corrie Pieterson, Andrea Kreuter, Jessica Alexander, and Varun Gadkari, as well as Biology 1113H students in spring semesters of 2013–2016. Special thanks to the Center for Life Sciences Education. This project could not have been done without our community partners: Nancy Kaufman, Laura Wieck, and Annie Nelson with MMORE, American Red Cross organizer Cat Elkins, and Waterman Farms director Glenn Mills. Finally, thanks to Ola Ahlqvist and Harmony Cox of The Ohio State University Service Learning Initiative, who provided valuable feedback and grant support to develop this course.

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