5-2021

The Impact of Service-Learning on General Chemistry II Students at the University of Nebraska at Omaha

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University Honors Program Thesis

Submitted by:

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May 2021

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Abstract

Service-learning has been shown to enhance academic and leadership skills while promoting community engagement and exposing students to different career opportunities (Esson et al., 2005). While the benefits of service-learning courses are clear, few STEM courses include service-learning components (Esson et al., 2005). Here, students in a totally online 2nd semester UNO chemistry course completed a service-learning project where they remotely led a live, inquiry-based STEM activity for Girl Scouts. To quantify the impact of service-learning on professional development, future career plans, and future volunteerism, a series of pre and post surveys were administered. Paired-sample t-tests revealed a statistically significant increase in the development of leadership and communication skills, as well as the likelihood of future community engagement following completion of the service-learning experience. While not significantly altered, future career plans may have been reinforced rather than changed. Additionally, because the nature of the service-learning experience was an informal science education activity, a statistically highly significant increase in the confidence at explaining complex scientific topics to younger audiences resulted. Such beneficial outcomes provide considerable support for the importance of including service-learning in STEM courses throughout undergraduate education as the beneficial outcomes are vital for preparation for further professional school as well as entrance into the workforce.

Keywords: service-learning, college students, general chemistry, informal science activity, professional development outcomes, future volunteerism outcomes.

Introduction

Universities aim to produce not only knowledgeable and skilled graduates, but individuals who are actively engaged in their communities (Weiler et al., 2013). While content knowledge is essential in graduates, it is also important for graduates to be valuable members of the community and knowledgeable of "volunteer opportunities…, nonprofit organizations…, and of contemporary social issues" (Weiler et al., 2013, p. 237). As such, communication, diversity skills, and self-efficacy are all additional valuable components of an ideal graduate (Weiler et al., 2013). Providing college students with opportunities to engage in service-learning is one way to provide students with these attributes. Accordingly, colleges across the United States have increasingly incorporated service-learning projects into regular course curriculum. At the University of Nebraska at Omaha, "community engagement and service are fundamental components of UNO's identity… [with] commitment to engagement… reflected in UNO's academics, student body, partnerships, and institutional framework" ("Engagement," n.d.).

Bringle and Hatcher (1995) define service-learning as "a course-based, credit-bearing educational experience in which students (a) participate in an organized service activity that meets identified community needs and (b) reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility" (p. 112). Service-learning experiences vary in the length of commitment with short-term experiences lasting from the duration of the semester to a singular day (Tryon et al., 2008). Through service-learning, students discover and experience invaluable "frustrations, challenges, and rewards" (Esson et al., 2005, p. 1168) when applying course content to real life situations (Simons & Cleary, 2006).

Service-learning not only contributes to deeper learning of course material, but also engages students with the community while promoting civic engagement in the future (Shelby et al., 2013). Positive outcomes of service-learning for students includes: "increased academic, interpersonal, and leadership skills; increased community engagement; exposure to career development opportunities; improved self-esteem, self-efficacy, and self-confidence; [and an] increased ability to apply course concepts to new real-world situations" (Esson et al., 2005, p. 1168).

Service-learning engagement results in increases in leadership, communication, confidence, and problem-solving skills (Tucker & McCarthy, 2001; Weiler et al., 2013). These skills are essential for college students to develop throughout their education as such "skills are critical to effective job performance, career advancement, and organizational success" in their near future (Tucker & McCarthy, 2001, p. 227). Tucker and McCarthy (2001) revealed that service-learning could be used to boost student confidence levels at giving presentations since service-learning provides opportunities for students to present in front of diverse audiences in regard to "age, experience, and knowledge" (p. 228). Service-learning increases the student's ability to work as a member on a team by providing students with opportunities to work with diverse groups of students with differing thoughts and opinions (Mitchell & Rost-Banik, 2019). All of these qualities: leadership, communication, problem-solving, self-confidence, and teamwork are essential for entrance into the workforce after graduation.

While students' development of professional and interpersonal skills is impacted by engaging in service-learning, future career goals are affected as well by either reinforcing their current career path or guiding them down a different path. By participating in service-learning opportunities, students have the ability to observe different occupations in the real world,

broadening students' perspectives on the types of professions that can be accomplished with their course of study (McGowin & Teed, 2019). In a survey conducted by Simons and Cleary (2006), 82% of respondents identified service-learning experiences as contributors to their career development. Thus, service-learning experiences can either confirm a students' career aspirations or modify it (Simons & Cleary, 2006) since these experiences "shape students' interests, values, skills, and self-efficacy" (Mitchell & Rost-Banik, 2019, p. 19).

Through engagement with service-learning, civic responsibility is instilled in students, increasing the likelihood of serving the community in the future (Tucker & McCarthy, 2001; Weiler et al., 2013; Tomkovick et al., 2008). In a study conducted by Tomkovick et al. (2008), it was revealed that students engaged in service-learning that attribute an increase in their professional development to the experience are more likely to serve the community in the future. Furthermore, an increase in likelihood of future volunteerism was observed when service-learning participants felt that their time was of great "value to the organization and its clientele" (Tomkovick et al., 2008, p. 15).

In addition to the aforementioned service-learning benefits, participation in service-learning courses also provides valuable service experience that is a significant portion of graduate and professional school applications. As a result of the coronavirus pandemic, traditional service opportunities are much less commonly available and therefore, service-learning opportunities are even more important and valuable. While "the American Chemical Society (ACS) Committee on Professional Training (CPT) has stated that chemistry students must develop communication skills, master problem-solving, and be able to function effectively as part of a team," few chemistry courses incorporate service-learning even though it would be an ideal way for students to achieve such outcomes (McGowin & Teed, 2019, p. 2158).

Therefore, the current study incorporates a service-learning project, in the form of an informal science education experience, into the curriculum of a General Chemistry II course. This should not only benefit the college students facilitating the service-learning project, but also the youth participating in the informal science activities, especially during the coronavirus pandemic in which many similar activities have been suspended or interrupted (Weiler et al., 2013).

Here, students in a totally online Spring 2021 UNO chemistry course completed a service-learning project where they remotely led a live, inquiry-based STEM activity for Girl Scouts. Groups of 8-10 students chose either to adapt an existing activity or develop their own. It was hoped that students would view this service-learning project favorably, that it would enhance development of their professional & interpersonal skills, and that it would increase their interest in future community engagement. Thus, this study aims to reveal the impact service-learning has on students' professional development, future career goals, and future volunteerism. It is hypothesized that our findings will support previous literature in which the addition of a service-learning component to General Chemistry II will enhance professional development and increase the likelihood of future community engagement, while possibly reinforcing future career paths.

Service-Learning Project Description

Participants

Students in the study were from a single General Chemistry II course, spring 2021, at the University of Nebraska Omaha (IRB # 511-15-EX). The course contained 183 students: 68 males and 115 females; 14.21% freshmen, 36.07% sophomore, 32.24% juniors, and 13.66% seniors; the remaining 3.82% were in post-baccalaureate or graduate programs.

Target Audience

The target audience for this informal science activity was Girl Scouts. These were middle school students ranging from 4th to 8th grade.

STEM Lesson Plans

Available lesson plans were provided from NE STEM 4U and previous Magic of the Chemistry Workshops ("NE STEM 4U," n.d.), though some groups chose to create their own. Since these lesson plans were written for in person instruction, they needed to be modified for execution through a remote format.

Project Timeline

Two weeks into the Spring 2021 semester, 23 groups were finalized, with each group containing 6 to 10 students. First, groups had to choose a previously designed lesson plan or create one of their own. Next, a date was chosen in March or April to execute the lesson plan with the Girl Scouts via Zoom. Then, they completed a lesson-plan for their science activity. This included: finding 1-2 associated NGSS standards, creating a concise, specific student objective; defining student learning outcomes; defining vocabulary words used in the science activity that may be unknown to this age group; creating a list of materials that each Girl Scout would need to participate in the lesson, with a budgetary limit of $15 per participant; developing a specific and age appropriate procedure; developing guiding questions to ask the Girl Scouts before, during, or after the activity; writing background information on the specific topic; providing several examples of future career applications; and developing a list of sources. Each groups' list of materials was to be sent to Dr. Richter-Egger at least 10 days before each groups' presentation so the material list could be sent to the Girl Scouts with adequate time to purchase the necessary materials to participate in the lesson. In addition to these steps, the groups also

beta-tested their activity with an audience of their choice (middle schoolers, friends, or family) if possible. Next, 5 days before each groups' presentation, a walk through with Dr. Richter-Egger or a peer-mentor was conducted along with a confirmation of which group members were presenting. Additionally, a photo release for the presenting members was completed. Finally, the final presentation of the science activity was conducted in March or early April.

Preparation

Preparation for the successful execution of the lesson plan (via Zoom) for Girl Scouts in March/ April included: modification (or creation) of the lesson plan for an online delivery format; development of hand-outs that included background information and future applications; creation of the PowerPoint to assist with online delivery; development of pre-recorded video clips of sections of the activity; and completion of the outline and beta testing. Given the large nature of the groups, most groups divided these roles among group members.

Informal Science Activity Execution

The actual informal science activity, led by 2-3 students per group, included live interaction with the Girl Scouts using remote delivery (via Zoom). This format allowed for parents to supervise the Girl Scouts while college students directed them through the STEM activity, answering their questions in real time. Most groups planned for (and gave) approximately 30-minute presentations to an audience of 10-30 Girl Scouts over Zoom with supervision from UNO and Girl Scout leaders. While live, real-time interaction was intended, three groups pre-recorded their lesson plan due to last minute scheduling conflicts.

Course Points

Successful preparation and execution of this service-learning project was worth 65 points out of a total of ~1100 points for the course. Graded assignments included: submission of STEM

topic and lesson plan (3 points); finalization of presentation date (3 points); creation of the outline of the activity (8 points); successful beta test of the activity 5 days before presentation (12 points); presentation of the activity to the Girl Scouts (24 points); group reflection on the content/delivery (10 points); and individual reflection on how this project impacted them individually (5 points).

Reflection

After the facilitation of the science activity to the Girl Scouts, General Chemistry II students reflected on this service-learning project in which they were asked to write one paragraph each on what went well, what needs to change if repeated, and a description of a success story. In the individual reflection, students were asked to write a discussion board post on how the experience was meaningful to them and to provide at least 3 thoughtful responses to their classmates' reflections. They were asked specifically how the project may have changed their interests/plans, view of service-learning, and desire to get involved in the community.

Methodology

Surveys

A pre-post survey (Table 1) was administered to General Chemistry II students prior to and after the completion of the service-learning project to quantify the impact that the addition of a service-learning component had on the: professional development (category 1), future career plans (category 2), and future volunteerism (category 3) of the students. Due to the nature of the service-learning project, an impact on the likelihood of continuing informal science education experiences was also analyzed unrelated to the research question (category 4)

An additional post-survey was administered to further analyze the impact on categories 1-4 as well as to quantify: the increase in understanding of STEM material (category 5), the degree

to which it benefited the community (category 6), and the worthiness of the program (category 7). While categories 4-7 do not directly provide information for answering the research question in this study, they were included to identify any other significant patterns in the impact of service-learning on the chemistry students. These survey questions, modified from a previous survey (Esson et al., 2005), are provided in Table 2.

Table 1: Pre and Post Survey

	Statements	Category
1	How would you describe your leadership ability?[a]	1
2	How would you describe your communication ability?[a]	1
3	How would you describe your ability to work as a team?[a]	1
4	I am confident in my ability to lead a group of my peers.[b]	1
5	I am confident in my ability to explain a complex scientific topic to middle school students.[b]	1
6	What are your future career plans?[c]	2
7	I am likely to continue to volunteer and serve the community after graduation.[b]	3
8	I am interested in pursuing informal science education opportunities.[b]	4

[a]Respondents were given the options of poor (bottom 25% of your peers), fair (below average but still above 25% of your peers), average (better than ~50% of your peers but not as good as the other ~50%), very good (top 25% of your peers), Excellent (top 10% of your peers).
[b]Respondents rated their agreements with the statements on a Likert Scale from strongly agree (5) to strongly disagree (1).
[c]Respondents were given the options of health professional (doctor, nurse, dental, PA, PT, etc), pharmacy, engineer, science education (k-12, college, formal and informal), or other.

Table 2: Survey Administered After the Completion of the Service-Learning Project

	Statements[a]	Category
1	This course enhanced my professional development.	1
2	Doing this service-learning project improved my problem-solving ability.	1
3	Doing this service-learning project improved my communication ability.	1
4	Doing this service-learning project improved my leadership ability.	1
5	Doing this service-learning project improved my ability to work with others.	1
6	Doing this service-learning project improved my confidence in my ability to explain a complex scientific topic to middle school students.	1
7	My experiences in this course altered my future career plans.	2
8	Doing this service-learning project helped me acquire knowledge and skills applicable to future career plans or professional school.	2
9	Doing this service-learning project makes me want to continue volunteering.	3
10	Doing this service-learning project increased my desire to teach others about science.	4
11	Doing this service-learning project increased my understanding of my group's STEM topic	5
12	Doing this service-learning project increased my interest in STEM topics in general.	5
13	Doing this service-learning project helped me see how STEM topics are relevant in my everyday life.	5
14	Doing this service-learning project benefited the local community.	6
15	I encourage the continuation of this service-learning project.	7
16	Doing this service-learning project was challenging.	7
17	Doing this service-learning was time-consuming.	7

[a]Respondents rated their agreements with the statements on a Likert Scale from strongly agree to strongly disagree.

Data Analysis

To quantify the impact that the addition of a service-learning component has on the professional development (category 1), future career plans (category 2), and future volunteerism (category 3) of General Chemistry II students, the raw data was transformed into a numerical analogue so that for each statement, the change in response between pre and post surveys could be calculated for each individual. For statements 1-3 (Table 1), the numerical analogue used follows: Poor (bottom 25% of your peers) =1; fair (below average but still above 25% of your peers) =2; average (better than ~50% of your peers but not as good as the other ~50%) =3; very good (top 25% of your peers) =4; Excellent (top 10% of your peers) =5. For statements 4-5 and 7-8 (Table 1), the numerical analogue used for the Likert scale was strongly disagree=1; disagree=2, neutral=3, agree=4; strongly agree=5.

General Chemistry II students with changes ranging from -3 to +3 between the two surveys were then counted and graphed as a percent out of 165 students who completed both surveys (Fig.1). Further data analysis of the pre and post survey included the calculation and comparison of the percentage of students selecting each response (see Appendix A) and the calculation of the average response and difference between the pre and post survey after conversion to numerical analogue (see Appendix B). 181 students completed the pre-survey, and 165 students completed the post-survey. For each statement in Table 1, a paired-samples t-test was conducted to determine if the difference in average responses between the pre and post surveys were statistically significant.

The percentage of students selecting each response on the Likert scale was calculated and graphed in response to the statements in Table 2, with statements in reference to categories 1-3 in

Figure 2, and categories 4-7 in Appendix C. For simplification, strongly disagree and disagree were added together, along with strongly agree and agree in Appendix C.

Results

The impact of this experience on the chemistry students' professional development, future career plans, and future volunteerism was quantified by analyzing the responses from surveys (Table 1, Table 2), administered before and after the completion of the service-learning project.

Professional Development

Analyzing the changes in responses to each statement at the individual level, the leadership ability of 25% of students' increased by one level after the completion of the service-learning project, with 54% students reflecting no change (Fig. 1). A paired-samples t-test was conducted to determine if the average responses between the pre and post surveys were significant. There was a statistically significant increase in reported *leadership ability* after the completion of the service-learning activity (M=3.436; SD=0.899) than before (M=3.279; SD=0.915); t (164) =2.73, p= 0.007. Furthermore, 31% of students responded one level higher on the Likert scale in regard to their confidence at leading a group of peers after the service-learning project in comparison to before, with 59% responding the same (Fig. 1). A statistically highly significant increase was also observed in the *confidence in leading a group of peers* after the completion of the service-learning activity (M=4.097; SD=0.718) than before (M=3.879; SD= 0. 697); t (164) =4.41, p= 1.84 $x10^{-5}$. Furthermore, after the service-learning project was completed, 14.02% strongly agreed and 53.66% agreed that their leadership ability was enhanced as a result of the project (Fig. 2).

In regard to communication ability, 27% of students rated their ability one level higher on the post survey in comparison to the pre survey, with 48% of students responding the same on both surveys (Fig. 1). A statistically significant increase was observed in *communication ability* after the completion of the service-learning activity (M=3.485; SD=0.921) than before (M=3.327; SD= 0.983); t (164) =2.73, p= 0.02. Furthermore, analysis of the post survey revealed that 26.22% strongly agreed and 54.88% agreed that the service-learning experience enhanced their communication ability (Fig. 2).

While 22% of students reflected that their ability to work as a member of a team was one level higher after the service-learning project than before, 50% of students reported no change in ability between the two surveys, and 19% of students reflected that their teamwork ability was higher before the service-learning project was completed (Fig. 1). After conducting a paired-samples t-test, no statistically significant difference in the *ability to work as a member of a team* was observed after the completion of the service-learning activity (M=3.818; SD=0.885) than before (M=3.776; SD=0. 879); t (164) =0.62, p= 0.54. However, in the supplementary survey, 23.78% of chemistry students strongly agreed and 56.71% agreed that their ability to work with others improved after the service-learning project was complete (Fig. 2).

When rating the degree of agreeing with the statement, "*I am confident in my ability to explain a complex scientific topic to middle school students"* on a Likert scale, 3% of students' responses increased by 3 levels, with 6% increasing by 2 levels, and 31% increasing by 1 level after the completion of the service-learning project (Fig. 1). Conducting a paired-samples t-test revealed a statistically highly significant increase in the *confidence in the ability to explain a complex scientific topic to middle school students* after the completion of the service-learning activity (M=4.000; SD=0.681) than before (M=3.521; SD= 0.874); t (164) =6.93, p= 9.16×10^{-11}.

Furthermore, 26.22% of students strongly agreed and 51.83% agreed that the completion of the service-learning experience boosted their confidence in their ability to explain complex scientific topics to middle school students (Fig. 2).

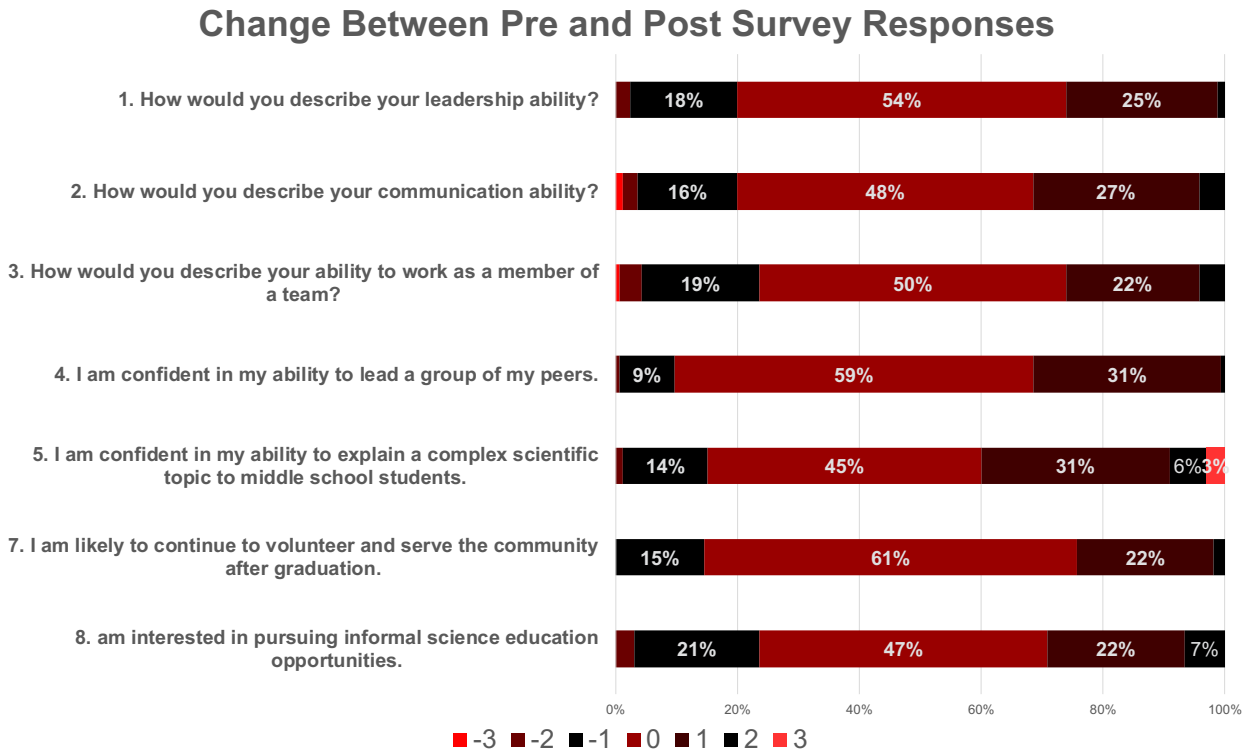

Figure 1: Change Between Pre and Post Survey Responses.

Pre and Post survey raw data (n=165) collected before and after completion of a service-learning project was transformed into a numerical analogue so that poor (bottom 25% of your peers)=1, fair (below average but still above 25% of your peers)=2, average (better than ~50% of your peers but not as good as the other ~50%)=3, very good (top 25% of your peers)=4, and excellent (top 10% of your peers)=5 for questions 1-3; whereas for questions 4-5 and 7-8, strongly disagree=1, disagree=2, neutral=3, agree=4, and strongly agree=5. General Chemistry II students with changes between the two surveys ranging from -3 to +3 were then counted and graphed as a percent to analyze the impact of service-learning on professional development (category 1), future career plans (category 2), and future volunteerism (category 3).

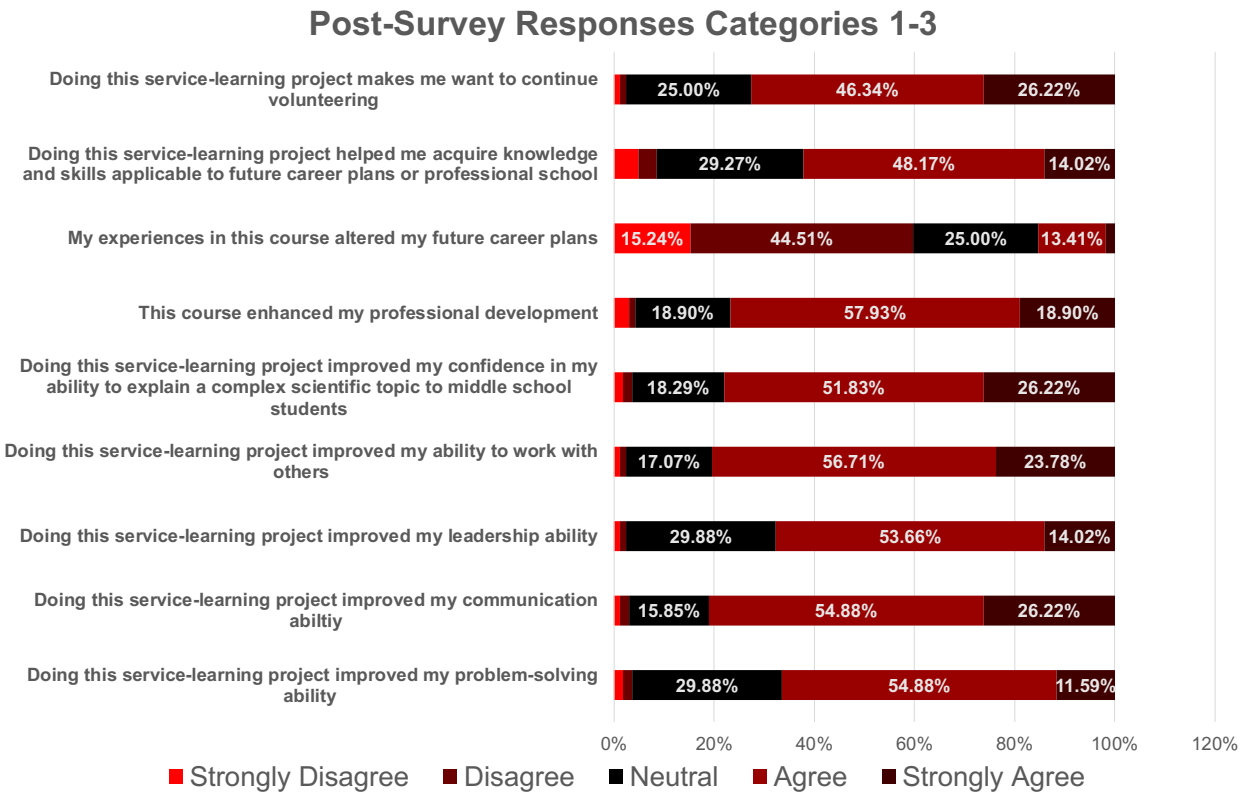

Figure 2: Post-Survey Responses to Statements Regarding Professional Development (1), Future Career Plans (2), and Future Volunteerism (3).

Survey responses to various statements were collected (n=165) after the completion of a service-learning project to quantify the impact made on General Chemistry II students' professional development (category 1), future career plans (category 2), and future volunteerism (category 3). Available responses ranged from strongly disagree to strongly agree on a Likert scale. Responses were counted and graphed as a percent.

Future Career Goals

Analysis of pre and post survey responses to statement 6 (Table 2) reveal a lack of significant career changes after the completion of the service-learning project, with the percentage of responses for each option as follows: engineers (6.67% vs 6.06%), health professionals (73.94% vs 72.12%), pharmacy (7.27% vs 6.06%), science education (1.21% vs 1.82%) and other (10.91% vs. 13.94%) (Fig. 3). When rating the degree of agreeing with the statement, *"My experiences in this course altered my future career plans"* on a Likert scale, 13.41% of students agreed, 25% remained neutral, 44.51% disagreed, and 15.24% strongly

disagreed (Fig. 2). Furthermore, 14.02% of students strongly agreed that the service-learning project helped them acquire knowledge and skills applicable to future career plans or professional school, while 48.17% agreed (Fig. 2).

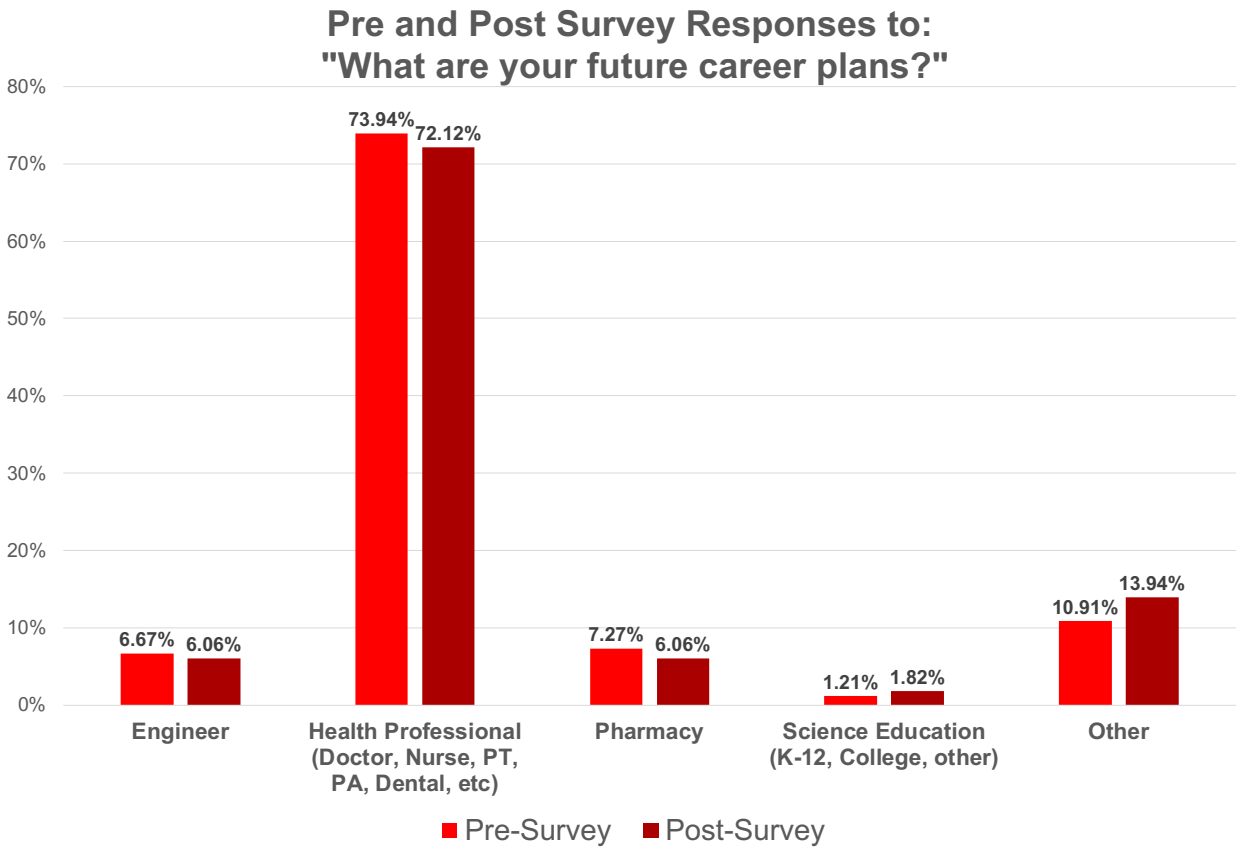

Figure 3: Comparison of Pre and Post Survey Responses to: "What are your future career plans?"

The responses of General Chemistry II students to "What are your future career plans?" collected before and after the completion of a service-learning project in a pre and post survey (n=165) were counted and graphed as a percent to analyze the impact of service-learning on future career plans (category 2). Participants were given the options of health professional (doctor, nurse, dental, PA, PT, etc), pharmacy, engineer, science education (k-12, college, formal and informal), or other.

Future Volunteerism

After analyzing the change in responses between pre and post surveys, when rating the degree of agreeing with the statement*, "I am likely to continue to volunteer and serve the community after graduation"* on a Likert scale, 22% of students' responses increased by one level after the completion of the service-learning project, with 61% responding that the likelihood remained the same after the service-learning project than before (Fig. 1). A paired-samples t-test revealed a statistically significant increase in the *likelihood of continuing to volunteer and serve the community* after the completion of the service-learning activity (M=4.303; SD=0.711) than before (M=4.188; SD= 0.729); t (164) =2.25, p= 0.026. Additionally, after the completion of the service-learning project, 26.22% of students strongly agreed that the completion of the project made them want to continue volunteering, whereas 46.34% agreed, and 25% remained neutral (Fig. 2).

Discussion

There remains a distinct lack of service-learning in STEM courses despite the numerous and well documented beneficial outcomes of service-learning, especially in regard to enhanced personal skills and future civic engagement. After analyzing the responses to pre and post surveys, administered both before and after the completion of a service-learning experience that included leading a hands-on STEM activity for Girl Scouts, it was revealed that service-learning enhanced the development of professional and interpersonal skills, increased the likelihood of engaging with the community in the future, and resulted in no significant change to future career plans.

Professional Development

As hypothesized, the completion of the service-learning project in this STEM course resulted in enhanced professional and interpersonal skills. Statistically significant increases in leadership and communication ability, and a statistically highly significant increase in confidence in leading a group of peers, are strong evidence of professional growth in these General Chemistry II students. Enhanced leadership and communication skills following service-learning experiences have been previously reported (Tucker & McCarthy, 2001; Weiler et al., 2013), and provide a valuable comparison for this current study. Since the nature of the service-learning experience involved working in groups of 8-10 students, the increase in leadership ability by one level in 25% of students coincides with the number of students stepping into the leadership role, either as leading the group through the project, dividing work amongst group members, organizing meeting times, and communicating with the instructor and peer mentor; or participating as one of the presenting group members who led the Girl Scouts through the activity. Enhanced communication can be attributed to group communication when choosing the topic and presentation date as well as communicating with the course instructor, peer mentor, and the Girl Scouts.

Since service-learning provides students with opportunities to work with diverse groups of people, from various backgrounds and all with differing thoughts and opinions, an increase in the student's ability to work as a member of a team was found in a 2019 study by Mitchell and Rost-Banik. However, in the current study, no statistical change in teamwork ability was discovered when pre and post survey responses were analyzed using a paired-samples t-test despite the group-based nature of the project. However, in the supplementary survey administered after the completion of the service-learning project, 80.49% of respondents agreed

or strongly agreed that their ability to work with others improved following the completion of the project (Fig. 2). This difference may be attributed to the self-reported nature of the survey responses as it is possible students over-exaggerated or under-estimated their teamwork ability when responding to the pre or post survey. Group members who struggled in communicating and reaching all members of the group as well as getting all group members involved in completing a portion of the project may have felt discouraged by group work by the end of the semester and thus responded differently than they may have if apart of groups with actively engaged members.

Since this service-learning project required the explanation of complex scientific topics to a younger audience of Girl Scouts, increased confidence in this ability was anticipated. The results show a statistically highly significant increase in the confidence of this ability after the completion of the project. This increase can be attributed to the various roles required for successful completion of the project, such as modifying (or creating) a lesson plan, creation of hand-outs with background information, development of a Power-Point or pre-recorded videos carrying out the activity, completion of the outline, and beta testing with other younger students and the instructor or peer mentor, all of which required deep thinking of how to explain a topic to a younger age group. Furthermore, 5 students' responses regarding their degree of agreeing with statement 5 (Table 1) increased 3 levels on the Likert scale, with 10 and 51 students increasing 2 and 1 level (s), respectively (Fig. 1). While 74 students reported no change in this ability (Fig. 1), in the supplementary survey, 78.05% of students either agreed or strongly agreed that completion of this experience enhanced their confidence at this task (Fig. 2). With approximately 73% of the students on the path to becoming a health professional, of which explain various health conditions to patients frequently, this finding alone provides clear evidence of the benefits of incorporating this service-learning project into the General Chemistry II course.

Future Career Goals

While previous literature revealed the significance of service-learning experiences in either changing the direction of future career plans or reinforcing the current path further (Simons & Cleary, 2006), the hypothesis that future career paths would not significantly change as a result of this service-learning experience was confirmed (Fig. 3). While 2-3 students per group may have experienced the joys of exciting students about science along with the challenges that come with teaching, the lack of repetition in these experiences makes it unlikely for future career paths to significantly change for such students. However, 13.41% of students agreed with the statement *"experiences in this course altered my future career plans"* (Fig. 2). This finding may be attributed to the interpretation of the word "alter" as such students may have felt that the service-learning experience reinforced their current career path, rather than changing it altogether, and thus agreed with the statement.

Future Volunteerism

It was expected, and hoped, that an increase in the likelihood of future community engagement following the completion of the service-learning project would ensue as it is well documented in literature (Tucker & McCarthy, 2001; Weiler et al., 2013; Tomkovick et al., 2008). This expectation was confirmed as a statistically significant increase in the likelihood of future community engagement was found after conducting a paired-samples t-test. Furthermore, these results confirmed previous findings from a study that determined that future civic engagement was increased when (a) participants of service-learning experiences attribute the experience to enhancing development of their professional and interpersonal skills, or (b) when participants felt that their time spent in the service-learning project benefited the recipients (Tomkovick et al., 2008). Since (a) can be seen by the statistically significant increase in

leadership and communication abilities and (b) can be seen in the finding that 82.32% of students either agreed or strongly agreed that completion of the service-learning project benefited the local community (see Appendix C), the statistically significant increase in likelihood of future community engagement provides further confirmation of the findings of the 2008 study by Tomkovick et al.

Additional Findings

In a survey administered after the completion of the service-learning project, responses were analyzed to quantify the impact of the experience on the students' likelihood of seeking further informal science education experiences, understanding of STEM material, and the worthiness of the service-learning experience. Since the service-learning experience involved researching a complex STEM topic and brain-storming ways to explain this to a younger audience, it makes sense that 77.44% and 59.14%, of students either agreed or strongly agreed that the completion of the service-learning experience increased their understanding and interest of the STEM topic, respectively, along with 77.44% agreeing or strongly agreeing that the experience helped them see how STEM topics are relevant in everyday life (see Appendix C).

Interestingly, while the future career plans did not change, 51.83% of respondents either agreed or strongly agreed that completion of the service-learning project increased their desire to teach others about science. While this result is less surprising from the students who led the science activity with the Girl Scouts (25%-38% of the total students), as witnessing the excitement and enthusiasm of the Girl Scouts is a rewarding experience, that does not explain the remainder of students agreeing with this statement. Therefore, this provides support that the preparatory roles of other group members resulted in an impactful and meaningful experience as well that increased their desire to teach others about science. Additionally, while 42.68% and

49.39% strongly agreed or agreed that the service-learning project was challenging and time consuming, respectively, 70.12% of the students agreed or strongly agreed that the service-learning project should be continued (see Appendix C). Thus, while it may have been challenging and time consuming, especially within the context of a rigorous General Chemistry II course, most students recommended its' continuation. This is strong evidence of a meaningful and impactful experience felt by the students.

Limitations

One limitation that existed is the self-reported nature of the data, in the form of responding to survey questions, that cannot be verified. The subjective nature of the survey questions was attempted to be overcome by providing more objective response options such as poor (bottom 25% of your peers), fair (below average but still above 25% of your peers), average (better than ~50% of your peers but not as good as the other ~50%), very good (top 25% of your peers), and excellent (top 10% of your peers), but responses may still suffer from bias in self-perception. These responses are also subject to the mood the participant is in when taking the survey. Towards the end of the semester when the post survey was administered, it is more likely for students to feel overwhelmed by the course load and rate their responses lower than they may have if the survey was given after the course was completed and their stress was relieved. While in the future, it would be recommended to minimize the likelihood of this happening by administering both surveys at a time with similar course workload, this was not possible due to time constraints. However, this is unlikely to have a large impact on the data presented due to the large sample size.

Implications

Statistically significant increases in both leadership and communication abilities, while expected, provide support for the incorporation of service-learning into STEM courses as such skills are necessary for both entrance into the workforce and for future professional and graduate school. Additionally, statistically highly significant enhancement in the confidence at explaining a complex scientific topic to younger audiences not only fills a gap in previous literature that lacked research regarding service-learning experiences, especially those involving an informal science education experience, but it also provides further support for the importance of these types of experiences, both in STEM and other courses, as this skill is useful in many careers. Lastly, the statically significant increase in future community engagement reinforces the findings from the 2008 Tomkovick et al study as results indicate both a statistically significant enhancement of professional and interpersonal skills, as well as the acknowledgement of community benefit that participants attributed to the completion of the service-learning project.

Future Directions

While the data indicates the current service-learning project having a significant impact on boosting professional and interpersonal skills as well as promoting future civic engagement, a future direction could include more frequent interactions with the Girl Scouts so that each member of the group would have an opportunity to lead the activity with the Girl Scouts. The results from that future study could then be compared to the current study to determine if further enhancement of professional skills and future volunteerism results from an increased number of students having direct interaction with the Girl Scouts.

Conclusion

The incorporation of a service-learning project, in the form of an informal science education experience, into a General Chemistry II course resulted in statistically significant enhancement in both the development of personal and interpersonal skills, as well as the likelihood of future community engagement. By incorporation of an informal science education experience into the service-learning project, a broader impact was made on the students through enhancement of their ability to explain complex scientific topics to younger audiences in addition to the deepened understanding and interest in STEM material. Such beneficial impacts fill a gap in literature as it relates to service-learning in STEM courses, while also providing supporting evidence as to the importance of the incorporation of service-learning into STEM courses in addition to the added benefits of including an informal science education experience. With most STEM students going onto further professional and graduate schools, the need for enhancement of such attributes during their undergraduate education is prevalent. With well documented evidence of service-learning enhancing such skills, as supplemented further by the results of this study, there is strong evidence for the positive impact made by incorporation of service-learning into undergraduate courses, including STEM.

Acknowledgements

I would like to express my deepest appreciation to Dr. Dana Richter-Egger for his valuable advice, constructive criticism, and unwavering support and guidance. Additionally, I would like to extend my sincere thanks to Dr. Lucy Morrison for her profound belief in my abilities.

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APPENDIX A

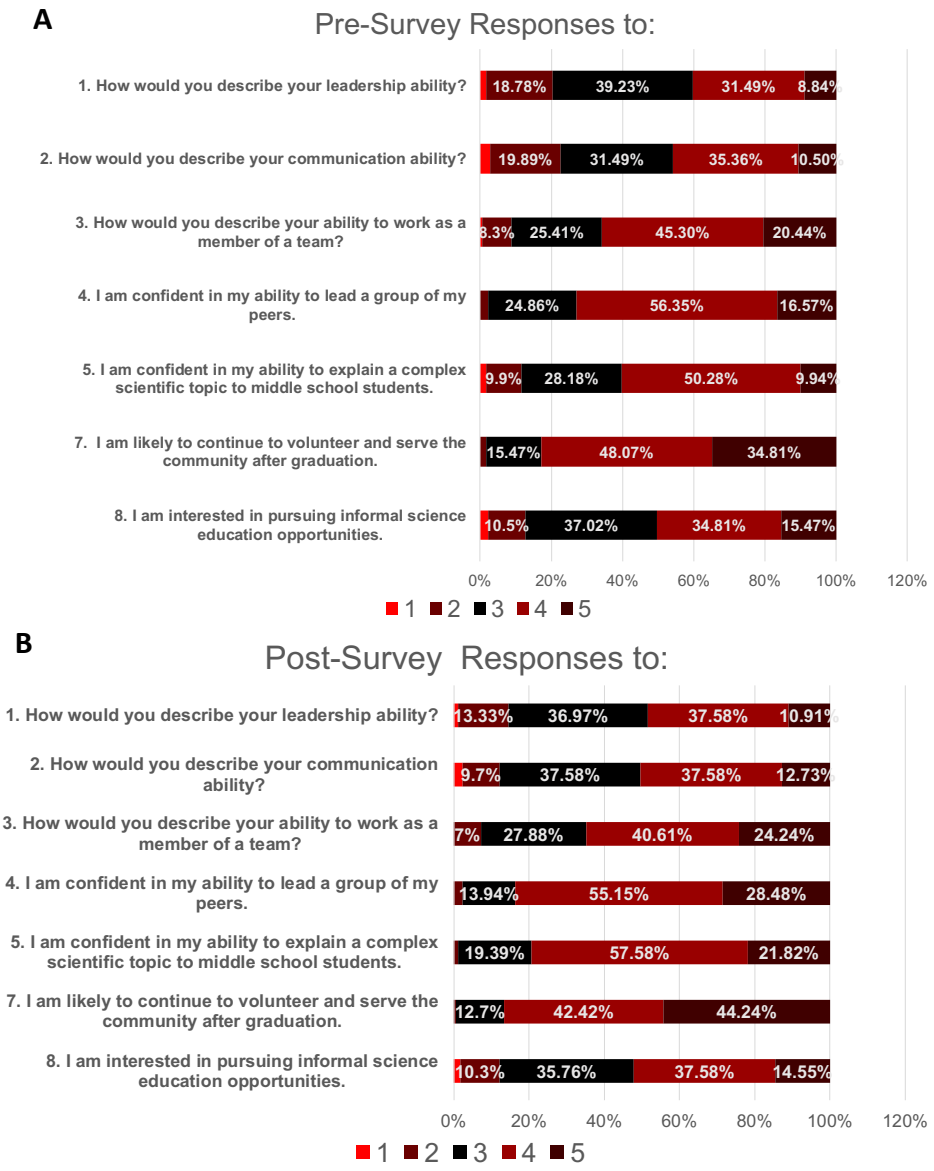

Figure 4: Comparison of Pre and Post Survey Responses

Survey responses to various statements were collected before and after the completion of a service-learning project in a pre (A, n=181) and post (B, n=165) survey to quantify the impact made on General Chemistry II students' professional development (category 1), future career plans (category 2), future volunteerism (category 3), and future seeking of informal science education opportunities (category 4). Available responses (and numeric analogue) for questions 1-3 were poor (bottom 25% of your peers)=1, fair (below average but still above 25% of your peers)=2, average (better than ~50% of your peers but not as good as the other ~50%)=3, very good (top 25% of your peers)=4, and excellent (top 10% of your peers)=5; whereas for questions 4-5 and 7-8, available responses were strongly disagree=1, disagree=2, neutral=3, agree=4, and strongly agree=5. Each available response was counted and graphed as a percent.

APPENDIX B

Table 3: Average Pre and Post Survey Responses

Statement	Pre-Survey (n=165)	Post-Survey (n=165)	Change
1. How would you describe your leadership ability?[a]	3.279 + 0.915	3.436 + 0.899	0.1576*
2. How would you describe your communication ability?[a]	3.327 + 0.983	3.485 + 0.921	0.1576*
3. How would you describe your ability to work as a member of a team?[a]	3.776 + 0.879	3.818 + 0.885	0.0424
4. I am confident in my ability to lead a group of my peers.[b]	3.879 + 0.697	4.097 + 0.718	0.2182**
5. I am confident in my ability to explain a complex scientific topic to middle school students.[b]	3.521 + 0.874	4.000 + 0.681	0.4788**
7. I am likely to continue to volunteer and serve the community after graduation.[b]	4.188 + 0.729	4.303 + 0.711	0.1151*
8. I am interested in pursuing informal science education opportunities.[b]	3.497 + 0.948	3.527 + 0.928	0.0303

[a]Poor (bottom 25% of your peers) =1; fair (below average but still above 25% of your peers) =2; average (better than ~50% of your peers but not as good as the other ~50%) =3; very good (top 25% of your peers) =4; Excellent (top 10% of your peers) =5.
[b]Strongly disagree=1; disagree=2, neutral=3, agree=4; strongly agree=5.
*Statistically significant, $p<0.05$
**Statistically highly significant, $p<0.001$

APPENDIX C

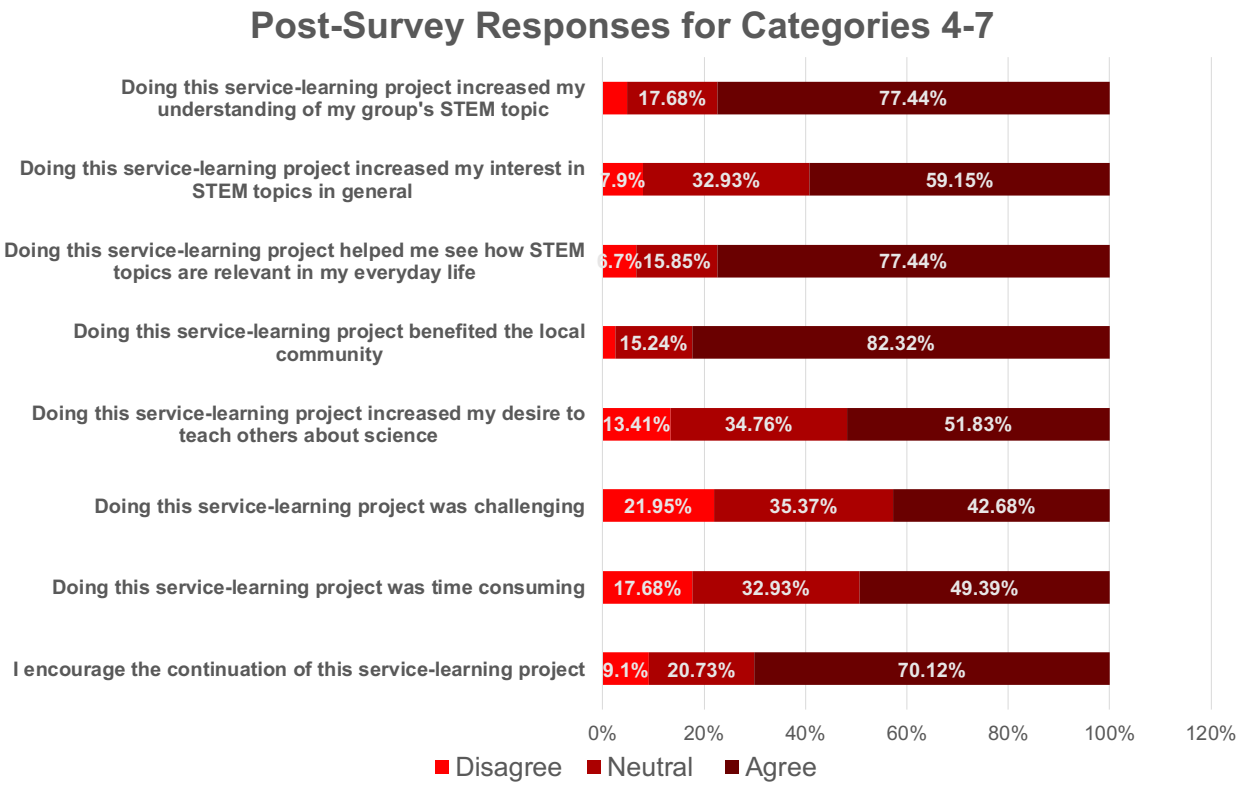

Figure 5: Post-Survey Responses to Statements Regarding Future Seeking of Informal Science Education Opportunities (4), Impact on Understanding of STEM (5), Degree to which the Community Benefited (6), and Worthiness of the Service-Learning Project (7)

Survey responses to various statements were collected after the completion of a service-learning project (n=165) to quantify the impact made on General Chemistry II students' likelihood of seeking further informal science education experiences (category 4), understanding of STEM material (category 5), community benefits (category 6), the worthiness of the service-learning experience (category 7). Available responses ranged from strongly disagree to strongly agree on a Likert scale. Responses were counted, strongly disagree and disagree responses were summed together (as well as strongly agree and agree responses) and then graphed as a percent.

APPENDIX D: IRB LETTER

University of Nebraska Medical Center
NEBRASKA'S HEALTH SCIENCE CENTER
Office of Regulatory Affairs (ORA)
Institutional Review Board (IRB)

December 2, 2020

Joshua Darr, Ph.D.
Chemistry
UNO - VIA COURIER

IRB # 831-20-EX

TITLE OF PROPOSAL: Assessment of General Chemistry curriculum taught using science practices

The Office of Regulatory Affairs (ORA) has reviewed your application for *Exempt Educational, Behavioral, and Social Science Research* on the above-titled research project. According to the information provided, this project is exempt under 45 CFR 46:104(d), category 1 and 2. You are therefore authorized to begin the research.

It is understood this project will be conducted in full accordance with all applicable HRPP Policies. It is also understood that the ORA will be immediately notified of any proposed changes for your research project that
A. affect the risk-benefit relationship of the research
B. pose new risks which are greater than minimal
C. constitute a new risk to privacy or confidentiality
D. involve sensitive topics (including but not limited to personal aspects of the subject s behavior, life experiences or attitudes)
E. involve deception
F. target a vulnerable population
G. include prisoners or children
H. otherwise suggest loss of the exempt status of the research.

You are encouraged to contact the ORA to discuss whether changes to exempt research requires review by ORA.

Please be advised you will be asked to update the status of your research yearly by responding to an email from the Office of Regulatory Affairs. If you do not respond, your project will be considered completed.

Sincerely,

Signed on: 2020-12-02 14:59:42.623

Gail Kotulak, BS, CIP
IRB Administrator III
Office of Regulatory Affairs