



# Student Reflections on Service Learning in Software Engineering and Their Experiences with Non-technical Clients

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## ABSTRACT

Participation in service-learning projects that impact society or serve the greater social good has been shown to have a broad range of positive impacts on students, including increased motivation and persistence, improved social outcomes, self-efficacy, and leadership skills, and an increased sense of civic duty. This paper describes a longitudinal study that examines the impacts of service learning projects on the students' perceptions about applying their knowledge and skills in a practical authentic context. The results suggest that while service learning has positive effects on student learning outcomes, there are challenges unique to software engineering projects done for non-technical clients that might not be present when similar projects are sponsored by industrial clients. This paper summarizes these challenges and describes a number of solutions that worked in our context.

## CCS CONCEPTS

• **Software and its engineering** → *Collaboration in software development*; • **Social and professional topics** → **Software engineering education**.

## KEYWORDS

Service learning, software engineering, capstone projects, non-profits, professional competencies, non-technical project clients

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## 1 INTRODUCTION

Service learning is defined as “a teaching and learning strategy that integrates meaningful community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities” [32]. Service-learning projects have a long history of being used as a context for integrative experiences in a variety of disciplines, such as engineering [6] and computing

[7, 28]. While current research reports are generally very positive concerning the effects of service learning on a variety of student characteristics, such as motivation and civic duty, there are few studies that examine a broader range of impacts of service learning on the student mastery of their technical and professional skills that are most directly related to their academic discipline, which would have a direct impact on building professional competencies of students. In this paper, we attempt to examine the effectiveness of a year-long service-learning experience on a small group of students from a sequence of two software engineering projects at CCSU.

## 2 SERVICE-LEARNING EXPERIENCES

The concept of service learning embraces the idea of positioning teaching and learning in a practical real-world social context [3, 17]. Service learning places students in an environment where they are exposed to various societal issues, unfamiliar perspectives, and diverse communities. Service-learning activities have been noted to have a broad range of positive impacts on students [1, 5]. Academic benefits of service learning include improved student ability to apply knowledge [24, 29], as well as increased motivation [27, 33] and persistence [8, 9]. Service learning can also strongly benefit students' social outcomes and improve their self-efficacy [7, 28], leadership skills [7, 24], increase the sense of civic duty [19, 20] and help them establish stronger career goals [5, 18].

Vogelgesang and Astin [3, 36] conducted a quantitative longitudinal study of over 22,000 undergraduate students attending North American colleges and universities. They indicate that participation in service-learning activities had positive impacts on students' academic performance (including critical thinking skills), values (including a commitment to bringing about positive changes to society), self-efficacy, and leadership. The report suggests that this is because students were “making a difference” and because they were discussing their work with each other and their professors, inside and outside of the classroom.

Some researchers indicate that it is difficult to assess student outcomes in courses that incorporate service learning, e.g. [34]. In particular, it is important to distinguish student satisfaction from student learning when self-reporting is used as an assessment instrument to evaluate service-learning activities [10]. To address that, Molee et al [26] describe the DEAL Model for student learning assessment that can be used for quantitative evaluation of student critical reflections by measuring the depth of learning and critical thinking. In this model, students reflect on their service-learning experience and examine their experience through the prism of academic enhancement, personal growth, and civic engagement. Furthermore, reflection is a critical part that distinguishes service learning from community service [1, 13, 16, 37]. By discussing both

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the project itself and their experiences of working on it, reflections can help students gain an appreciation for their role in society both as a citizen and as a professional. Reflections are essential to a successful service-learning experience as they enable students to make multiple strong interconnections between their learning outcomes and their engagement experience [2, 11, 14]. To overcome the stereotype of reflections being a better fit for a humanities course, some educators choose to embed such activities into various existing curricular elements, such as engineering design process deliverables or teamwork assessment [25, 35].

Overall, best practices of service learning include providing students with professional role models and creating an atmosphere for positive interactions in the context of an authentic real-world experience. One of the main tenets of the learning sciences is that students acquire deeper knowledge and skills when they participate in activities that mimic those of what professionals in their discipline engaged in on a daily basis [31]. Students also achieve the best results when they work on open-ended tasks and can seek feedback and help from others, including professional mentors, peers, or teachers [30]. In the computing discipline, such practices are typically centered around software engineering and include agile software projects that provide a rich foundation for teamwork, mentorship, and reflection [4].

### 3 STUDY DESIGN

We conducted a small-scale study to better understand the improvement in student skills and possible changes in their attitudes as a result of participating in service-learning projects.

CCSU offers an ABET-accredited undergraduate Computer Science program that requires students to complete a two-course capstone sequence, a traditional software engineering course and a senior design course, both of which incorporate a significant software engineering project. A sequence of different student teams works on these projects that span two, three, or more semesters. The prerequisites include a data structures course plus any two senior-level courses intended to equip students with software development experience. The first course in the sequence covers many topics typical for a traditional software engineering course reflecting all activities of the software development lifecycle. As a result, the embedded course project takes a somewhat slow start to make sure that all relevant conceptual material is covered before students can practice a given activity, e.g. requirements engineering, in their project. The development part of this project includes four two-week sprints. The project component in the second course in the sequence consists of six two-week development sprints. This course also includes readings and discussions of current articles, mostly from the IEEE Software magazine, on ethical and professional issues. All projects in these courses are sourced from external clients, which include large and small businesses, non-profits, and community organizations. Over time, the composition of these sources changed so that in the last few years most of our projects have been sponsored by not-for-profit organizations. This effort and the overall logistical structure of this project framework have been previously described in [23].

As described earlier in this report, there is a broad range of evidence documenting a variety of positive impacts of service learning.

Given the software studio format [21] of our project framework where projects persist for longer than one semester with multiple teams contributing to each project over time, we wanted to examine the specific impacts that service learning has on the formation of student competencies, their ability to apply knowledge, and further develop technical and professional skills.

We adopted assessment instruments developed by the HFOSS initiative to evaluate student participation [12, 15]. We modified some questions to the context of our project framework and added additional questions to include a range of software engineering competencies. The resulting assessment instrument contains 30 Likert-scale questions reflecting six constructs detailed in Table 1. When presented to students, questions were randomized. Additionally, students were asked to provide open-ended responses concerning their likes and dislikes, as well as the most and the least valuable aspects of their service-learning experience. This feedback was analyzed and broken down to reflect student opinions within each of the six survey constructs.

The assessment instrument was administered to two student cohorts who took the capstone course sequence in the 2021-22 and 2022-23 academic years. The survey was administered twice to each cohort: in September, at the beginning of the software engineering course, after students learned about the service-learning nature of the course project, and again, in May, when they were nearing the completion of the second course in the sequence. The phrasing of some questions in the pre-survey was adjusted to reflect that students have not yet started working on the project. Student responses from both cohorts were merged to increase the study population size. All students taking the surveys each semester participated in a service-learning project sponsored by a non-profit or a community organization. In most cases, students switched projects and teams after the first course. This was done intentionally to maximize student exposure to a variety of projects, technologies and tools, teamwork modalities, and communication styles. A total of 39 students completed both surveys. Our Institutional Review Board approved our plans to conduct this study and collect student feedback for research purposes. These students participated in a variety of projects that included:

- A scraper for a social media website that collects information about upcoming events in the given geographical area that would be safe for those currently in addiction recovery programs. The collected information is channeled to a WordPress website serving that community.
- A mobile application for calendar access, notifications, and management for a community of people with autism spectrum disorder and their families.
- A volunteer management and tracking system for a community health center providing free or low-cost healthcare services.

Analysis of the collected data is shown in Table 2. A two-tailed t-test was used to measure the impact of service-learning activities on the student outcomes as assessed by the pre- and post- metrics.

### 4 FINDINGS AND OBSERVATIONS

Our software project framework relies on project sponsors and student teams working together to achieve the project goals [22].

**Table 1: Survey Questions and Constructs.**

Construct	ID	Question
Application of Knowledge	AK-1	I am confident in the effectiveness of my computing skills
	AK-2	I've had ample opportunities to apply my knowledge and skills gained in other CS courses
	AK-3	I took part in a project that helped me to see practical applications of theoretical concepts from several areas of computing
	AK-4	I participated in a project that gave me a new perspective about applying computing to solve practical problems
	AK-5	I understand how different computing topics can complement each other to address specific requirements of various real-world problems
Serving the Greater Good	GG-1	I have a greater awareness of the potential for computing to benefit society
	GG-2	Participating in a project that serves the greater good inspires me to use my computing skills to help others
	GG-3	Knowing that this project will help other people motivates me to do my best on this project
	GG-4	I enjoy working on a project that allows me to participate in a diverse community of developers
	GG-5	Working on this project gave me a better appreciation for the usefulness of computing to serve the greater good
Impact of Scale and Complexity	SC-1	I can describe the impact of project size on the approaches used to develop software
	SC-2	I can describe the impact of project complexity on the approaches used to develop software
	SC-3	I am comfortable with working on a large software project along with many other developers
	SC-4	I am confident that I can maintain a complex software project
	SC-5	I can use modern software engineering principles to work on a complex real-world project
Use of Software Engineering Processes	SP-1	I am comfortable that I could participate in the planning and development of a real-world software project
	SP-2	I can list the steps in the software process my team used in this project
	SP-3	I am comfortable with using a software development process in a project
	SP-4	I am confident about my skills to collaborate with professionals from a variety of locations, backgrounds, specializations, and/or cultures
	SP-5	I can make substantive contributions to most activities in a software engineering project, including specification, design, implementation, and testing
Use of Soft Skills	SS-1	I have effective communication skills
	SS-2	I am confident in my ability to explain technical problems to non-technical people
	SS-3	My teamwork skills are effective
	SS-4	My time management skills allow me to get things done efficiently
	SS-5	I am confident in my ability to be an effective member of a software development team
Mastery of Tools and Technologies	TT-1	I can use all tools and techniques employed in this project
	TT-2	I have good skills to use distributed version control systems such as GitHub
	TT-3	I am comfortable with using remote collaboration tools used for pair programming
	TT-4	I can effectively participate in cloud-based project development and deployment
	TT-5	It is important to be able to learn new tools and technologies specific to a project

In a typical project, each sponsoring organization designates one person acting as a product owner who should be able to answer any questions about the desired software functionality. In our experience of working with non-profits that spans over eight years, most of these product owners lack the technical background or experience working with technical teams.

There was a common thread emerging from open-ended student feedback. Students consistently pointed out the fact that most individuals representing the client non-profit organizations lacked technical background, which impacted most facets of the student service-learning experiences reflected in this study. Although they were identified through the lens of student perception, they matched much of our prior experience. Here, we discuss the findings of our survey, along with the common pitfalls of working with non-technical project clients and the solutions that worked for us.

### 4.1 Application of Knowledge

The collected data suggest that there is a statistically-significant difference in student opinions concerning the practical application of theoretical concepts from several areas of computing and understanding how different computing topics can complement each other to address specific requirements of various real-world problems (questions AK-3 and AK-5). Indeed, our course projects typically brought together topics from various areas, such as databases,

web development, and algorithms. Many students appreciated the fact that these projects required them to apply knowledge and skills from different courses in an authentic context.

It was unlikely to expect every student to have knowledge and skills in all areas relevant to the specific project, but many teams were able to benefit from their collective skillset and experience:

In many computer science classes, the actual project feels irrelevant to the material in the course, this is definitely not the case in this course. In fact, in this project I was constantly using concepts from other classes. Having students who took classes on different topics helped us get all of our bases covered.

Many students noted that such an integrative experience would go a long way to prepare them for real-world challenges. This was further validated by a few students who already have experience working in the industry. Some of them indicated that they had taken courses before where they were told by professors that “you’ll need to know X when you get a job” but it never came true for them. But these students also said that the experience of this course project was very similar to their day-to-day work experience. In particular, one of these students noted how realistic many experiences are in the course project:

At least [in] our project, I felt it really reflected real life “mini-project”. All of the experiences, drama, writing, communications issues were fairly realistic. I have managed many

**Table 2: Survey Data Analysis.**

Question	pre		post		$\Delta$	p
	Mean	SD	Mean	SD		
AK-1	3.45	0.73	3.85	0.74	0.40	0.020
AK-2	3.49	0.64	3.72	0.69	0.23	0.130
<b>AK-3</b>	3.51	0.72	3.95	0.68	0.44	<b>0.007</b>
AK-4	3.54	0.76	3.90	0.68	0.36	0.030
<b>AK-5</b>	3.64	0.63	4.13	0.57	0.49	<b>0.001</b>
GG-1	3.87	0.66	4.21	0.80	0.33	0.048
<b>GG-2</b>	3.97	0.49	4.33	0.52	0.36	<b>0.002</b>
GG-3	3.90	0.72	4.21	0.73	0.31	0.065
GG-4	3.95	0.56	4.21	0.83	0.26	0.115
GG-5	3.56	0.82	3.97	0.63	0.41	0.015
<b>SC-1</b>	3.87	0.57	4.24	0.65	0.37	<b>0.009</b>
SC-2	3.74	0.55	4.03	0.81	0.28	0.076
SC-3	3.15	0.67	3.46	0.60	0.31	0.036
SC-4	3.28	0.56	3.41	0.55	0.13	0.310
<b>SC-5</b>	3.44	0.60	4.00	0.89	0.56	<b>0.002</b>
SP-1	3.69	0.80	4.10	0.81	0.41	0.028
<b>SP-2</b>	3.44	0.68	3.92	0.77	0.49	<b>0.004</b>
<b>SP-3</b>	3.72	0.76	4.21	0.77	0.49	<b>0.006</b>
SP-4	3.72	0.79	4.05	0.69	0.33	0.051
<b>SP-5</b>	3.69	0.66	4.10	0.60	0.41	<b>0.005</b>
SS-1	3.59	0.72	3.87	0.61	0.28	0.066
SS-2	3.67	0.81	4.08	0.66	0.41	0.016
<b>SS-3</b>	3.85	0.59	4.20	0.53	0.35	<b>0.006</b>
SS-4	3.51	0.60	3.56	0.91	0.05	0.770
SS-5	3.87	0.70	4.28	0.72	0.41	0.013
<b>TT-1</b>	3.41	0.91	3.97	0.78	0.56	<b>0.004</b>
TT-2	3.36	0.87	3.79	0.61	0.44	0.013
<b>TT-3</b>	3.69	0.61	4.15	0.63	0.46	<b>0.002</b>
TT-4	3.26	0.88	3.59	0.72	0.33	0.070
<b>TT-5</b>	3.97	0.58	4.38	0.63	0.41	<b>0.004</b>

projects in my life and I have to say it was very close to reality. I think this is very important for the students. These kids might not know it, but they are getting a really good experience.

**4.1.1 Non-technical clients need help translating their knowledge and ideas.** In order to apply their knowledge and skills to solve a practical problem, students need to have an understanding of some elements of the problem domain, just as a project client needs to have an understanding of the team's capabilities to create a technical solution to solve the problem. Working with non-technical project clients presents a range of unique problems stemming from the fact that there is usually little to no overlap between the clients' problem domain knowledge and the students' subject domain or background knowledge. We believe that this disadvantage can be turned into a learning opportunity. As one student pointed out,

I enjoyed talking with customers and figuring out what they wanted to translate it into code and use what we've learned over many different courses. It was rewarding to watch all of it come together in a more meaningful way.

We believe that it is very important to manage non-technical clients' expectations, which must be approached as an ongoing process starting well before the project commences. Students need to be well-informed that most of the individuals representing a non-profit lack any technical background. We also instructed these individuals that they cannot expect students to know any specific details concerning their problem domains. These efforts of managing mutual

expectations usually pay off resulting in many students enjoying and appreciating the results of their interactions with their project clients.

## 4.2 Serving the Greater Good

Student feedback was overwhelmingly positive about the effects of serving the community and the greater good on the student motivation to work hard and do their best on these projects. In particular, there was a statistically significant difference in student responses to question GG-2 that reflects the motivation to do their best on this project because it benefits other people. Most students indicated that while working for a real-world client made them take their work much more seriously, having a project client that works on addressing a societal need made a very significant difference. The following quote illustrates this sentiment:

I think it has been a great opportunity to work with an actual non-profit. I feel like it has put more pressure on me than any other project in another class because I have a real incentive to get it to work properly because of the causes and people they serve.

**4.2.1 Non-technical clients can help provide additional motivation for students.** As noted above, some of our past projects included those sponsored by various businesses and, in particular, several well-known insurance companies. Informal feedback from the past teams who worked on projects sponsored by such clients indicated that students were generally motivated by solving technical challenges specific to each project, as well as by the need to meet course expectations in terms of earning good grades. Many projects sponsored by non-profits provided an additional layer of motivation where students strive to perform better because they know that their work may make a difference in their own or another community and benefit individuals in need. This sentiment is reflected in the following student comment:

The project clients not being some insurance-based company makes it feel more rewarding to complete the project.

## 4.3 Impact of Scale and Complexity

Many of the classes taken by students previously included course projects, and some of them involved teamwork. However, except for students with prior industrial experience, these software engineering projects were the largest they ever participated in. Student response data suggests that participating in these service-learning projects had the biggest effect on their understanding of the impact of project size on the approaches used to develop software (SC-1) and the ability to use modern software engineering principles to work on a complex real-world project (SC-5). Survey data indicates that the difference in pre/post student responses was statistically significant for these two questions.

When reflecting on the impact of scale and complexity, some students noted that the project aspects they enjoyed the most were the opportunity to work with larger-scale applications and discover how software components interact and work together to comprise a fully functional product. They also pointed out that the combination of technologies involved in a single project of this complexity is such that it is impossible for one person to know all of them. Similarly, students noted that they've witnessed first-hand that due to the

size of the project, it would not be feasible for a single person to implement it, and that effective teamwork and collaboration with others is the only solution to working on a larger-scale project. In particular, one student noted:

Working with other like-minded people on coding and finding solutions really helped me understand the amount of learning it takes to be part of a process like this and has opened my eyes to the real effort that it takes to pursue similar large projects in the future.

**4.3.1 Non-technical clients may cause significant scope creep.** Some product owners contributed to a significant scope creep due to their own lack of clear vision for the outcomes of the project. Due to no fault of their own, a typical non-technical client may assume that computer science seniors are as capable as software engineers with a decade of experience. They may also assume that creating a certain software feature is as easy as drawing an icon for a mobile app because that is what they associate with its actual functionality. A non-technical project client frequently operates under the assumption that everything is very easy to implement and, consequently, it's not a big deal to make significant changes or additions to the project requirements. One student pointed out:

The major thing I dislike about the project is the indecisiveness of certain clients. We're getting brand new details every week that changes the major foundation of the program itself.

Although changing requirements and scope creep is something that does happen in real-world projects, pre-project negotiations with the project clients are key to minimizing these aspects. The aim of these negotiations is to reduce the scope creep as much as possible so that we can ensure that each team can make a meaningful contribution while still experiencing real-world challenges.

#### 4.4 Use of Software Engineering Processes

Student survey data suggests that working on these projects had a strong positive impact on student understanding and following a software process, as well as the students' ability to contribute to the software engineering project activities, including specification, design, implementation, and testing. This corresponds to questions SP-2, SP-3, and SP-5 where the difference in pre/post student responses was statistically significant.

Our project framework gives students an opportunity to participate in all activities of the software development process. Many students noted that they appreciated that their project started by interacting with the project sponsor to create a set of requirements to be implemented that semester. The agile software process was used to provide scaffolding not only for the project itself but also to provide students an opportunity to reflect on their progress in the form of in-class sprint retrospectives. Students indicated that they enjoyed applying the agile process while learning it, which helped them in planning the project and managing individual team members' responsibilities. Some students noted that sprint retrospectives were instrumental to keep the team on track:

The scrum meetings were enjoyable since they didn't feel very formal but gave us a chance to talk about what we've completed and plan to complete for the sprint. It kept our group honest and on track to complete the sprints.

**4.4.1 Multiple deliverables help clients navigate the project.** A project structure aligned with a fixed number of two-week development sprints provided substantial scaffolding support to the student teams. As one student noted, this helped keep everyone on track:

I think my favorite aspect of this project is how it's broken down into deliverables. The deliverables are a great way to keep the class organized and it helps everyone keep track of their time constraints. This has more to do with the fact that the clients this semester are non-profits and don't understand much when it comes to software engineering.

This scaffolding was also useful to the non-technical product owners who were reminded to expect regular interim demonstrations and check-ins with the student teams. Although the non-technical project clients were not expected to act as project managers, their lack of experience in participating in technical projects was usually detrimental to the project's success. However, having a clear sequence of deliverables indicating what they can expect from the student team helped us keep everyone on board. In particular, it helped us reduce any lapses in substantive and constructive feedback to the teams about their deliverables that we previously encountered when working with non-technical project clients. These deliverables can include design sketches, requirements specifications, demonstrations, technical documentation, etc.

#### 4.5 Use of Soft Skills

Although in-class retrospectives provided an opportunity for students to practice their communication skills, our projects offered many ways to improve other non-technical (soft) skills. Based on the student responses, student teamwork skills improved significantly as suggested by a statistically significant difference in pre/post responses to question SS-3. Somewhat surprisingly, students reported the smallest change in their time management skills (SS-4), which could possibly be explained by the fact that students were distracted by other responsibilities in their last semester before graduation and that they were being honest about it.

The majority of students mentioned that they enjoyed the teamwork aspect of these projects, which helped them to build on and leverage each other's existing skills.

Despite some issues, working with others was a blast and really helped create a sense of what being a software developer in the real world is like on a small scale. Things have been relatively smooth and I enjoy the fact that I most of the time have a second pair of eyes on my code. If I make a mistake, chances are one of my teammates might know the issue.

**4.5.1 Clear line of communication helps catch many red flags.** A substantial amount of effort was dedicated to educating each project client about the timeliness and transparency of communication and the importance of providing students with the information they need when they need it. However, despite our efforts to explain the nature of software projects and a number of reminders throughout the project, some sponsors were not effective in providing interim feedback to students. This student quote summarizes this sentiment:

While I like the fact that we get to work with clients, [our product owners] haven't been great in terms of giving feedback. Every time we have a meeting with them they usually just tell us everything is great and it feels like we are pulling

teeth with them. Also, they don't respond very quickly to emails when we need information or have questions.

At the same time, having a process framework that requires frequent meetings and feedback loops serves a significant purpose both for students and clients. In our experience, most technical clients representing various business entities find it very easy to follow, given that most of them have experience with project management. However, with non-technical clients, it is very important to provide them with an established timeline of expected meetings and the kinds of feedback they would need to provide to students. Unlike technical clients, many non-profit representatives need periodic reminders that their feedback to students needs to be timely and substantive, without which student teams will not be able to make meaningful progress. Having a clear and direct line of communication with the project client is key. Furthermore, it is also important to find a meaningful way to monitor communication between the project client and the team. On some occasions, the instructor was a part of Slack or Discord communication channels where all routine client/team communication took place. On other occasions, the instructor relied on students to report any potential red flags indicating that the client is missing or late to meetings or is not providing the answers or information they promised to deliver in a timely manner. Any such red flags would call for an immediate intervention by the instructor who would reach out to the project client and remind them about their commitment to the project's success. When working with technical clients, it is usually student teams who generate most such red flags.

#### 4.6 Mastery of Tools and Technologies

Despite the required prerequisites, it was inevitable that most students would need to learn new technical tools, development techniques, and software technologies in order to successfully participate in the projects. Although most students were familiar with using git and GitHub, they needed to learn how to use the feature branching git workflow. The student survey responses suggest that there was a significant improvement in their ability to use the tools and techniques employed in this project (TT-1). We made a very heavy emphasis on practicing pair programming, both in a physically shared space and in a remote environment, although this was not a requirement and there was no feasible way to enforce this. The data suggests that students became significantly more comfortable with using remote collaboration tools used for pair programming, as well as learning new tools required for a specific project (TT-3 and TT-5). Finally, there was a statistically significant difference between the pre/post student responses.

Although some students were initially uncomfortable with the idea that they have to learn new tools, most of them appreciated this opportunity and understood how it supports the concept of lifelong learning. In particular, one student noted:

The best part about this project was forcing me to branch out into learning new technologies that I wouldn't have otherwise learned anywhere else. It's a pretty good parallel to the real world because software engineers have to learn as they go.

Some students enjoyed not only learning specific new tools that were required for a given project but also appreciated a chance

to explore a range of options to improve both the team's working process and the project outcome for their project sponsor:

Choosing which technologies we want to use and figuring out the best ways to track information gathered from our client was eye-opening because we quickly found ways to improve our process.

*4.6.1 We need to meet non-technical clients where they are.* Today's students (as well as faculty working with students on the projects discussed here) are used to and prefer platforms such as Discord and Slack to communicate with each other. Many students view email as too formal, inefficient, and outdated:

I didn't like the client's method of communication (email). We've been responding to the same email chain with our client all semester and it's kind of a mess.

And yet, for many non-technical project clients, especially those who are at least a decade older than students, email remains the most common method of communication. Our attempts to encourage these project clients to adopt the communication systems used by students were not always successful because this usually adds an unnecessary technical barrier. We believe that it is very important to use a set of technical tools for communication, document sharing, video conferencing, etc., that a non-technical client would feel comfortable with in order to minimize their learning curve. Typically, we would discuss the client's preferences during our pre-project negotiations to make sure the choice of these tools facing the project client is not left up to the students.

## 5 LIMITATIONS

This study was limited by a number of factors. First and foremost, it was conducted within a small group of students who took a two-course sequence and completed both pre- and post-treatment surveys. This study covered students who participated in a year-long service-learning experience. Comparing these results with those reflecting the projects sponsored by an industrial partner could yield potentially interesting insights into how service learning compares to broader experiential learning in terms of improving student learning outcomes delineated by the survey constructs listed in Table 1.

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## 7 SUMMARY

Despite the limitations of this study, we believe that the findings described here reaffirm the benefits of service-learning projects in computer science and software engineering education. However, successful agile software projects require frequent engagement with the project customer. In the service-learning context, student teams are very likely to work with people from non-technical backgrounds. Although the quantitative results of this study suggest that students were still able to significantly benefit from this service-learning experience, student feedback indicates that there is a lot of room for improvement to ensure that this lack of technical background and understanding of the software development process by the project clients does not prevent students from achieving successful project outcomes.

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