Balancing Student Learning and Community Relations in Software-Based Service Learning

Nusaybah Abu-Mulaweh, Purdue University, West Lafayette

Nusaybah Abu-Mulaweh is a Continuing Lecturer in the EPICS Program at Purdue University in West Lafayette, Indiana. She received her Bachelors of Science in Computer Engineering from Purdue University Fort Wayne, and received her Master of Science in Electrical and Computer Engineering from Purdue University in West Lafayette, Indiana. She is currently pursuing her PhD in Engineering Education at Purdue University in West Lafayette, Indiana.

Dr. William "Bill" C. Oakes, Purdue University-Main Campus, West Lafayette (College of Engineering)

William (Bill) Oakes is the Director of the EPICS Program and one of the founding faculty members of the School of Engineering Education at Purdue University. He has held courtesy appointments in Mechanical, Environmental and Ecological Engineering as well as Curriculum and Instruction in the College of Education. He is a registered professional engineer and on the NSPE board for Professional Engineers in Higher Education. He has been active in ASEE serving in the FPD, CIP and ERM. He is the past chair of the IN/IL section. He is a fellow of the Teaching Academy and listed in the Book of Great Teachers at Purdue University. He was the first engineering faculty member to receive the national Campus Compact Thomas Ehrlich Faculty Award for Service-Learning. He was a co-recipient of the National Academy of Engineering's Bernard Gordon Prize for Innovation in Engineering and Technology Education and the recipient of the National Society of Professional Engineers' Educational Excellence Award and the ASEE Chester Carlson Award. He is a fellow of the American Society for Engineering Education and the National Society of Professional Engineers.

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Abstract

Service-learning is a form of experiential learning that integrates academic learning objectives with community engagement. It can develop both technical and the broad professional skills needed in today's global economy and is well-matched to the literature on diversity. In engineering and computing education, service-learning is typically project-based where students develop a project that adds value to the community partner. At a large Midwestern university, a design-based service-learning program engages students in teams that partner with local and global community partners to develop technological solutions to human, community and environmental needs. This article presents a case study of a software-based service-learning design class with multi-disciplinary students from varying academic levels, first-year to final year. Students are required to complete weekly reflections which were analyzed to attain insight into their experience. The study provides insights into how the students attempt to balance their own learning, project implementation, and community relations and impact while developing software solutions.

Introduction

Service-learning or community-engaged learning has seen a significant and growing interest within engineering and computing education as a means to meet learning outcomes, integrate professional preparation into the curriculum, and address human and environmental needs within our local and global communities. While engineering and computing have been slower than other disciplines to adopt the pedagogy, there are many examples of successful programs in engineering [1-5] and computing [6]. The pedagogy has been integrated into many disciplines and has shown to enhance learning, motivation, retention and diversity and in particular within engineering and computing education [7-13]. In the U.S., students have initiated numerous chapters of Engineers Without Borders U.S.A. (200+), Engineers for a Sustainable World (30+), and Engineering World Health (20+). One of the newest and fastest growing divisions of the American Society for Engineering Education (ASEE) is the Community Engagement Division. EPICS in IEEE is a signature program of the IEEE Foundation. The U.S. National Academy of Engineering included community-based programs in their exemplars of "Infusing Real World Experience into Engineering Education" [14].

An example that includes engineering and software community-engagement is the EPICS Program that has engaged students at Purdue University for more than two decades. It has grown significantly in size and breadth to where it is recognized as an independent academic program within the College of Engineering with dedicated laboratories and teaching staff. In the Fall semester of 2018, over 700 were enrolled and engaged in more than 150 projects with 57 community partners. While the program began within Electrical and Computer Engineering exclusively, it has become explicitly multidisciplinary with an average of about 40 majors participating in a typical year, and it includes students in their first-year to their fourth or final year. Each department, or school, determines how EPICS counts in their own curriculum. In four engineering majors and Computer Science, EPICS can be used as a capstone course. First-year

engineering students can participate through a Learning Community and use EPICS as a substitute for the first-year introduction to engineering courses. For all of the engineering disciplines, EPICS courses fulfills at least a technical elective. The curricular structure is designed to allow students to participate over multiple semesters or even years which supports long-term, reciprocal community partnerships. The long-term student participation allows projects to be developed over multiple semesters or years and allows projects in EPICS to address complex and compelling needs in the local or global community.

EPICS teams, or course sections, each consist of 8-25 students and are student led with a faculty or industry instructor, which we call an advisor. Graduate student teaching assistants support the advisors and each one supports 3-4 sections providing a mechanism for consistency across teams. Each team or course section comprises multiple sub-teams, each one of which supports a single design project. Once a project is delivered, a new project is then identified by students under the guidance of their faculty mentor(s) and community partner(s). Example projects include designing assistive technology for people with disabilities, developing database applications for human service agencies, and developing energy-efficient and affordable housing solutions [15].

Most of the teams or course sections are structured with a common community partner for all of the projects within that team or section. The exception are the teams with software projects. Several years ago, the software projects were pulled out into themes to allow these teams to support multiple partners who needed similar software solutions but require customization to their specific needs. This study focuses on students working within these software-based teams and projects to examine how they balance their own learning, the drive to complete a project and the community awareness and relationships. We have one main guiding research question: How do students balance learning, project implementation, and community relations in a software-based service-learning design course?

Methods

Service-learning is a pedagogy in which students engage in activities that address societal needs while simultaneously addressing student learning objectives. A facet that distinguishes service-learning from community service, is reflection [16,17]. Students gain an appreciation for the role they can play in society as a professional and citizen by reflecting on various factors to their project and experience. Significant research shows that reflection is a benefit to learning in general and within service-learning connects and depends the learning and community experience [18.19]. Research has also shown that reflection enhances learning in any learning setting [20], but within service-learning, it is imperative to connect the different elements of the learning and engagement experiences and allow students to process their experiences.

Traditional modes of reflection include journal writing and group discussions [16-19]. Journal writing provides a safe environment for students to express their thoughts and feelings and group discussions present an opportunity to express one’s views and to learn from other points of view. Students can also reflect on the impact they have by answering reflection questions or responding to question prompts. When designing service-learning projects, they can be set up analogously to traditional design projects but with an authentic partner who will be the

user of the product if successful. The reflection deepens the design experience and links the work with the broader societal issues being addressed by the partner and project.

One of the traditional barriers to integrating reflection into engineering or software courses has been the perception or stereotype that reflection is an activity that would fit into a humanities course but not an engineering course. One approach is to imbed reflection activities as part of design, project development or analysis of the learning outcomes, such as the design process and team dynamics, the reflection process has been put into a form that is more familiar and comfortable for the students and faculty [21]. Engineering service-learning has shown examples of reflection imbedded and explicitly designated as separate activities [1,6,22,23].

Reflection has become more recognized within engineering education as an acceptable activity and has become more widespread [24,25]. The EPICS program shifted from imbedding the reflective activities into other "engineering" activities to an explicit part of the expectations of the course.

Critical thinking, reflective judgment and the associated skills are an important educational outcome for engineering and computing students and are explicit learning outcomes for the EPICS Program. The development of these skills enables undergraduates to develop a broader appreciation of concerns facing their profession. Traditionally, reflective judgment within engineering and computing service-learning has focused primarily on the social, political, and cultural impact of technology on society. This emphasis notwithstanding, the EPICS program recognizes the value of reflective judgment and has attempted to expand the use of critical thinking skills to include reflections on the community partner (called the project partner), team dynamics, the design process, and ethics [23].

This approach is consistent with the broader ABET program and the characteristics of the Engineer of 2020 reported by the NAE [26]. Direct contact on projects with groups such as not-for-profit organizations and the reflection on the impact a student is making on these groups, rudimentary in service-learning, are aligned with these program outcomes.

EPICS students are required to maintain a design notebook. Students are expected to write about their work and accomplishments for the week and an explicit reflection on at least a weekly basis. A final reflection is also required of all EPICS students at the end of the semester. The final reflection serves as the culmination of their service-learning design experience in EPICS. At the beginning of the semester, students are given guided questions and topic areas to help them reflect. Although we have these guided questions and topic areas, ultimately, students choose what they want to reflect about.

The weekly and final reflections from one software oriented team with 4 students were evaluated for this exploratory study. This team worked on a new project with local city officials as the community partners. The purpose of the project was two-fold: (1) to educate and spread awareness to the public on the historical significance of the city and (2) to help city officials keep track and maintain documentation of historical sites in a uniform way. Therefore, the team designed a web application with a public user side and admin side. The ultimate goal was to develop a working alpha version of the website by the end of the semester.

Students were placed on this project based on their expertise, grade level, preference and needs of the team. Ideally, an EPICS team should be comprised of students with varying complimentary skill sets and academic levels. This helps to balance the team because while some students learn most of the time while on the project, there are also students who have the expertise and can push the project forward. Table 1 shows the team make-up with students' names replaced with pseudonyms per the university's IRB protocol. The EPICS program has a long-standing exempt protocol to use student artifacts that are developed as part of the course and have been de-identified. Along with their academic level and major, Table 1 shows each student's expertise level. The levels correspond to each student's familiarity and experience in coding, with low meaning very little to no experience and high meaning senior level of experience. The total number of reflections each student submitted is also shown in Table 1.

Table 1. Team Members on Software Project in EPICS

Student Pseudonym	Level	Major	Expertise Level	Total # of Reflections
Heather	Junior	Mechanical Engineering	low	13
Adam	Senior	Computer Engineering	high	11
Richard	Sophomore	Computer Engineering	moderate	15
Todd	First-Year	Undecided	low	12

Using an inductive thematic analysis [27], each reflection was coded independently and analyzed for emerging themes. The data from the student reflections can be a rich source of their perspective because they are given autonomy to write about what means most to them each week. All of the reflections were read multiple times by the researchers. Themes emerged and after developing these themes, the reflections were coded and example quotations were identified.

Reliability, Validity and Bias

In qualitative research, reliability refers to whether results are consistent with the collected data [28]. Reliability in this study was achieved through triangulation of data, which included coding and categorizing of themes found in the students' reflections and observational data from the instructor. The themes were independently reviewed by another researcher, co-author, not associated with the design team. The differences in the coding and categorizing was resolved through discussion and iteration on the coding schemes. Validity is partially addressed through the observations of the instructor who is also the researcher. Any qualitative data is subject to bias of the researcher and it is vital for the researcher to understand and mitigate the impact of that bias. This was done through the iterations with the co-investigator and subsequent discussions that were designed to elicit and address areas of bias. The findings were further validated by comparison with other data collected from students and alumni, which are discussed later in the paper.

Findings

In the next section, we present the themes that resulted from an inductive thematic analysis on 51 reflections written by four students working on the same web application. Three themes with four subthemes emerged from the data

1) how students perceived learning
    a) technical and
    b) professional skills,
2) how students perceived they were accomplishing project goals, and
3) the perceived relationship they had with the community partner
    a) the impact of their project and
    b) the impact of the community on themselves.

This section will focus on unpacking each theme with supported quoted evidence from the reflections.

Theme 1: Learning

The first theme that emerged involved the perceived knowledge the students were acquiring. The knowledge ranged from technical software skills they learned in order to contribute to the software project, and the professional skills they learned to be able to communicate their ideas and work as a team and with their community partner.

Technical Skills

Learning technical software skills was seen as a theme across all student reflections regardless of their academic level and expertise. For the most part, the reflections discussed how they learned skills new to them. For example, Adam stated:

> This week for me was a continued learning experience on security. I had to learn about how to handle user registration on a web platform. While creating the registration page I really tried to think about who would be using it and under what circumstances it would be used. With this in mind I tried to shield the page as much as necessary so that not everyone could access it with ease.

Although Adam had previous coding experience, he learned to acquire new knowledge in order to contribute to the security aspect of the website. His reflection also highlights the human-centered design process he took by developing the registration page with users in mind.

Adam also went on to discuss how this learning was important for not only his current success on this project, but how this learning will also benefit him in his career. He stated:

> This week showed me further importance and deeper understanding of various security concepts that I am sure will come in handy when I go to industry after graduation.

Therefore, students are learning new technical skills for the success of their project, but they are also realizing the benefits for their future careers. While the senior level student saw the benefits for his future career, the first year student saw the benefits for his current endeavor in his undergraduate career. Todd stated:

> Together we learned CSS and HTML in a productive and efficient way. Later in the semester, we learned to perform collaborate coding through Sublime Text and inserted

> housing data into the [redacted] sever through MySQL. I would like to pursue a certificate in computer engineering. These skills I learn in [redacted] team will definitely help along my way towards my degree.

Todd gained technical skills that helped the project and insight on what to pursue during his undergraduate career.

Heather discussed how she needed to research some information new to her on HTML and how she learned it. She was the project manager and also shared how she learned about communicating technical and disciplinary knowledge. She stated:

> I learned that even if you understand what is going on, others may not. These two weeks, I worked on the user guide. I may understand how the websites works up and down, but others may not understand the basics of the website. I learned that to help them understand, it was best to make a written guide to help guide them through a process. I am glad that I learned this before going into the work force.

She specifically identified how this experience and learning about communicating technical knowledge is preparing her for the workforce. Learning technical software skills were amongst the skills that were constantly talked about, however, professional skills like communication with all audiences and teamwork were also highlighted in the student reflections.

Professional Skills

Teamwork and communication were among the skills that were highlighted in student reflections as very significant and were discussed as early as week 1. Due to the nature of EPICS, students from different backgrounds and experiences are working together and relying on one another to collaborate and develop a product for the community. For example, Todd stated:

> By dividing up the work I got to focus on the coding language learning intensively. I have no coding experience of web page development. I took me a lot of time to get use to reading the code. It was especially helpful to get help from my senior and junior teammates. They have done a lot of coding experience and gave me many learning recourses. I realized the importance of working in a group. We help each other and achieve goals that I can't do it myself.

He realized the significance of teamwork and how a team can accomplish a lot more when working together. Todd also recognized the benefit of working in a team with mixed backgrounds. By having team members who had coding experience, peer-to-peer mentorship enhanced the learning of students who had very little to no coding experience.

In order for teamwork to work, communication needs to be strong within the team. Communication must also be strong with the community partner. This importance of communication was stated in Richards reflection:

> At the end we shared our method on the database and discuss about how to name each information for the building. In the beginning we set section as our building number. However, [community partner] indicate it is kind of misleading so we changed this category name as location which is more appropriate choice. From this I understand the importance of

> providing correct or appropriate information not only toward customer but also project team. Sigle wording error of a certain input can sometime create a misunderstanding throughout the whole.

Richard realized the significance of communication between the community partner and the team. Communication can benefit their project or have unintended consequences depending on whether or not the right information was communicated.

It was noteworthy that the students were very honest and self-aware of their limitations in some of the professional skills and were open about discussing it. Heather, as project manager, during the first week identifies and discusses an area of weakness, a correction and the implications for her future career:

> During this week, I learned that I have a weakness in communication. I need to figure out away that will be easy for me and the other teams to communicate with each other. To solve this problem, I decided that I want the groups to send me their PIGs to my email, and if they have any problems within their groups, they can have one spokes person to come talk to me. I believe it will be easier this way to keep everything organized. I am thinking that I might want to be a manager later in the future, but we will have to see as the weeks go by!

She later discusses in two consecutive weeks her fears of oral communication and how she can improve:

> This week I learned how to prepare for a presentation. I'm really shared of presenting. I get really nervous, but I learned that a presentation is just like a conversation. Easy, sweet, and to the point type of conversation.
>
> I learned that I have to be more confident in my ability to present. To have confidence, I will need to know my information, present like I'm taking to a friend, and be positive. Because I have a better understanding on why I'm scared of presenting, I can strengthen this skill to improve it for the future. This is a very important skill to have in the work force, and I am glad that I have the chance to work on it during this class!

Heather identified her weakness in presenting and worked towards achieving better presentation skills. The opportunity to present her project in front of varying audiences helped her overcome her fear and learn how to communicate her ideas more effectively. Todd also identified communication as a weakness. He shared in the first week how he knew he needed to work on communication and volunteered for a leadership position that would give him experience:

> In the first week of class, I learned what positions are in the [redacted] team. I chose to be the Project Partner Liaison because as an foreign student, I want to improving my communication skills.

Like Heather, Todd realized his weakness in communication, and therefore pursued an opportunity to help him learn and advance his communication skills.

Theme 2: Implementation

The second theme that emerged involved the perceived process in which students met project goals and implemented their software application. As perceived by the students, the center of this

service-learning design experience was the goal to achieve a working alpha version of the web application for the community partner. Therefore, the approach and decisions made by the students were based on achieving this ultimate goal.

Although we expect students to spend time learning particular software skills on the software projects, regardless of their level of expertise, students are encouraged to not spend the entire semester learning a specific coding language and/or concepts. After given some guidance on the basics of a particular coding language and/or concept (from their faculty/industry advisor, online resources, and peers), students are encouraged to 'learn as they go' while diving into the development of their application. For example, Heather stated:

> After learning the basics from week 7 and 8, I started putting my knowledge into creating a basic design for the website. I wrote a basic code with headings, paragraphs, and titles. I worked on the second page of the website and made the top part of it with the description of St. Mary's. The page doesn't look that lovely, but that is for the next week to improve the look. Because I learned HTML, it helped the project move forward which is very important. I reached my goal on time and helped my group with the project!

After learning the basics by mid-semester, Heather was ready to start developing basic code. She realized that the user interface was not the best quality as of yet, however she discussed how she will continue to spend time making improvements. We also see how Heather ties back any learning and development she made progress on as significant for achieving the ultimate goal. The 'learn as you go' process was taken up by the students, and we also see students following the human-centered design process we teach in EPICS. For example, Richard stated:

> Also the design of placing a actual map beside the district name is a very human-centered design, this is because most of people will have better understanding on a single term of word if there is a visual aids beside of it. The addition of the map will let user to have more direct view of what they are selecting which result in providing more information without enhancing any stress on user.

Richard mentioned using the human-centered design process while developing one the features in the application. Therefore, students are designing and developing with users in mind.

In this particular team, students new to coding were focused on learning HTML and CSS to work on the frontend of the website, while two advanced students with prior coding experience were focused on the backend, server side, and security aspects of the project. Heather stated:

> During these two weeks, I learned the importance of teamwork. [Todd] and I have been working on page two for two weeks before this. I worked on the top part of page two and he worked on the rating system. After working on our parts, we came together to put our parts on the same page. We combined our parts by communication and teamwork. I learned that even though one person can do all the parts, it is more convenient to work in a group because you get the work done faster and have more than one opinion on the matter, which will help strengthen the project.

Therefore, as discussed earlier, students leaned on teamwork to learn, however, they also leaned on teamwork for implementation. Heather emphasized how as a team, they were able to split the work and implement different features simultaneously. She also highlights how teamwork brought different views and therefore, different insights that helped advance the project.

Theme 3: Community

The third theme that emerged involved the community exposure the students experienced. Students highlighted the importance of maintaining a relationship with the community, the impact their project would have on the community, and how the community impacted them.

Relationship

Relations with the community begin prior to the beginning of the semester. The EPICS administration typically establishes initial contact with a community partner. The initial meeting between the community partner and the students for this particular team was setup by the instructor. Relationships are continued between semesters as long as there is mutual interest and opportunities for mutual value-add on both parts. The students met with their community partner in the second week and completed a needs assessment. Several students reflected on their experience after the meeting. Communication between the community partner and students was managed during the semester through a project partner liaison. The project partner liaison is a formal EPICS role in which a student is assigned to manage contact and communication with their community partner to provide a single point of contact for the partners. For this team, the project partner liaison was Todd, who, as mentioned earlier, took the role believing it would help his communication skills. In his reflections, He talked about the initial meeting:

> In the second week of class we got a precious chance to meet our [community partner]. He told us his expedition of the product, which is a website which documents all the historical buildings of district [redacted]. As an liaison, we exchanged emails and contact information for further appointments and progress update. At the end of the day, I sent out an thank you letter to our client appreciating his visit. That was the first thing I learned as a PPL. Nevertheless, I got more work to do in the future, not just simply sending out "Thank you" letters.

Therefore, we can see the initial meeting with the community partner as a needs assessment in which the students learn about the community partner and his needs. Todd also emphasizes that there is more work to be done to continue a relationship with the community partner. In another meeting with the community partner, new realizations come to light. For example, Todd stated:

> During our meeting, [community partner] mentioned that he would like a colored band that indicates the district that the user is currently at. To be honest, this is a very simple task for us to add in the band. However, if today [community partner] was asking something that requires us to change the entire design? We could have avoid this by constantly updating our design to him. Keeping our project partner in the game is the most important task for the Project Partner Liaison, which is my position. After the meeting, I learned to update our progress to [community partner] more often.

Similarly, Adam stated:

> This week really showed me the importance of interacting with our project partners. If we had not done this we would be working with our own assumptions which did not align with what the project partner needed. It showed me in the importance of gaining constant feedback and keeping in touch with our partner. He saved a lot of trouble and no matter what projects I work on in the future, getting the customer or the final users to interact with my work on a regular basis will be a priority for me.

Todd and Adam emphasized the significance of maintaining constant communication with the community partner. They specifically highlight this importance for the sake of the project's progress. Therefore, again we see the central point being the project's progress and that even maintaining a good relationship with the community partner is for the ultimate goal of their project's success.

Impact

Along with discussion of the relationship the students built with the community partner, students also highlighted the impact their project would have on the community. As stated by Heather:

> The smallest things can help a community. By making a website about historical buildings, it will help the people in the community understand the importance of the past. This will help even people who aren't in the community to see the historical buildings around them. Our project might be small compared to others, but it still has an effect on others. I learned this week that the simplest things can make a difference, so I started reflecting on how important our project really is.

Heather realized that although their project seemed small from her point of view, their project could make a big difference in how the local community and the outside world viewed the city. By developing an application that streamlines the way the city officials track historical buildings, the students were impacting the community in ways they did not know they could. For example, Adam explained:

> All in all, [community partner] constantly spoke about how maintaining these sites brought added value to the community. Maintaining these architectural sites led to more tourists coming into the area thereby adding more value to the [city's] economy. It also led to businesses wanting to move into the region which further stabilized the region. These learnings really matter because this setting resembles a cycle. The returns to the community are directly proportional to the effort put in by the various organization and residents. If everyone does not participate, it leads to the community not bring preserved which lead to its own problems (eg. Crime, building wear etc). To me, another aspect about that I found particularly informative was that a lot of people are not aware of the value in their local communities. They neglect it and decide to travel further out in search of things to see and do. However, no matter where one stays, their local community is valuable and residents should make an effort to try and learn about this community in the hopes of improving it.

Therefore, through communication with the community partner, Adam was able to understand the underlying significance of the project they were working on. Students are understanding why their project is important and the potential impact it can have on the community.

While students were aware of the impact their project could have on the local community, students also discussed how the community had an impact on them. For example, Todd explained:

> [The community partner] expressed his sorrow as he saw houses that was both historical and meaningful to be torn down since on one wants to spend money to maintain it. This got us to

> the point that we should set up the website as fast as possible and start to save precious data in an electronic form. Simply by documenting history, we are preserving the lost of valuable ideas and parsing our ancestor who brought us to this point.

After seeing the community partner's frustration, Todd was motivated to get things moving quickly on the project in order to address the community's concerns. Therefore, students gain motivation from their community partner. Another example of this motivation is seen in Richard's reflection:

> His passion toward those preserved historical building is extremely big. Therefore currently he is still doing a job of being a advisor on how to manage those historical building as a city officer. His passion is very visible from outsider. Every time I ask for any design changes and idea of taking those photo, he is always very interested. He is consistently active to our project and really wanted to witness the success of the project. From this I fully learned how important is to love your job. Existence of the love toward the job will create ultimate motivation to work more and contribute more. Therefore it is crucial to gain interest on any future works.

The community partner's passion motivates students to work hard, but it also showed Richard the importance of loving what you do. Therefore, Richard gained insight on what to look for in his future career.

Discussion

In the following section, we will address the research question by discussing the balance and obstacles within a software-based service-learning design course based on the students' perspective. We will also triangulate the instructor's perspective on the balance and the obstacles students face. Lastly, we will highlight the limitations of the approach and suggest areas for future research.

The Balance

Throughout the service-learning experience in EPICS, students balance learning, project implementation, and community relations. Through the students' reflections for this particular software project, insights were gained on (1) how students perceived learning technical and professional skills, (2) how they perceived accomplishing project goals, and (3) how they perceived their relationship with the community partner including the impact of their project and the impact of the community on themselves. Based on the reflections, students centered their actions on project progress. Whether it was communicating and maintaining a relationship with the community partner, learning new skills, and/or developing code for their web application, every action was made for the sake of progressing the project.

Although the three themes were separated (learning, project, and community) in order to unpack and understand how students learn, implement, and maintain community relations, these themes overlap and intertwine. The weekly reflections showed students moving between them during the semester with different students identifying different themes in most weeks.

There are times in the semester where the students lean towards one of the three areas. Most students started with issues about teaming and communication as the teams got started. Building a relationship with the community and learning comes before project implementation begins and this was especially true with the teams personally meeting the partner in the second week of classes. As they begin project implementation, learning and community relations are intermixed with issues of the design itself and meeting deadlines. Community relations and impact come into play when they generally interact with the partner or are needing input and feedback.

The balance seen in these reflections is similar to what has been seen in other data from the overall program. In particular, a study of alumni [13] found that it was the interplay of these dimensions that was cited by graduates that created the exceptional learning experience. The graduates found that the balance of the real project with a real user but within a safe learning environment created a synergy that was valuable for learning and produced tangible outcomes for the community partners.

Overcoming Obstacles

As students navigate balancing different aspects of service-learning, they run into obstacles and learn to overcome them. Based on this team's reflections, it was apparent that the team relied on teamwork, and specifically peer-to-peer mentorship to overcome obstacles. When learning code and software concepts, the students with low expertise level in coding relied on their peers who had more experience and knowledge to help them learn. Also, while developing code, they relied on each other to implement features and reach deadlines and goals.

There were no obstacles when communicating with the community partner. From the perspective of the students, the community partner was always engaging and ready to help in any way. The community partner was also local, therefore, it was very easy for students to visit the project partner when needed, and the community partner to be able to come to them as well. The only shortcoming that was highlighted by the students was when they went a month without communicating with the community partner. Although they were busy implementing features on the website, they realized that even in development it is important to keep communication alive so that the community partner can follow along and make any changes early if needed.

Instructor Perspective

From the instructor's perspective, the students moved between the different themes naturally depending on the state the project was at. There were times students needed prompting and guidance in the right direction. For example, when deciding between different technology stacks. The students were always advised to consider the supported technologies at the university and to make sure those were supported by the community partner's technology department. Aside from design decisions, there were times students needed to be prompted to shift their balance. For example, students tended to focus on learning every aspect of the coding language, and therefore, really needed to be pushed to jump into development. Students quickly learned how much faster they are able to learn once they began coding and developing features.

Students were also encouraged to continually reach out to the community partner. They were encouraged to visit the community partner to see the historical sites, to constantly update the community partner on their progress, and to seek feedback on their designs and development. There were times when students needed to be prompted to reach out to the community partner and/or get approval on designs and changes as they progressed through the project. Once they were developing features, students did not feel it was necessary to update and/or communicate with community partner till the project was completely done. Waiting for certain features to work before showing them to the partner was understandable. However, at times the behavior of waiting till later to reach out to the partner became a habit and features were completed without any insight from the partner. Therefore, students needed to be prompted to show the progress to the community partner to gain feedback sooner than later in case changes needed to be made. They ultimately learned the importance of the constant communication.

Implications for Future Instruction

This study demonstrates the insights that can be gained by evaluating student reflections and examples of the learning made explicit through reflection. The students on the software team developed the habit of weekly reflections and it became part of their weekly work. The many benefits of learning through reflection mentioned earlier [16-25] were brought to the software team. The reflections offer a means for instructors to see on a regular basis how students are managing the balance of the dimensions of their learning and the project work and can be used to prompt students to address areas that may be neglected.

By monitoring and understanding how students manage to balance and prioritize on software service-learning projects, instructors can better guide them in their service-learning experiences. Sometimes the balance may lean towards one of the themes of learning, implementation, and/or maintaining community relations, and sometimes these themes overlap and intertwine. Instructors need to be aware of the tendency for students to focus on learning every aspect of a particular coding language. Based on this experience, students needed to be prompted and encouraged to begin development. Student also needed prompting when it came to communicating with their community partner and to take their needs and perspectives continually into account. Instructors need to be aware of the communication occurring between the students and the community so that they are able to intervene when necessary. Corrections can be made through explicit instructions or prompts for reflective thinking that offer students the opportunity to self-correct.

When it comes to design decisions, instructors for software service-learning should be involved in making sure the right technology stack is chosen. Making sure students choose the right technology stack for their project avoids hurdles and issues like compatibility later on. Even if there are students with expertise, mistakes can happen, and advising the students from the beginning prior to development helps avoid these mistakes. As with any learning, it is optimized when students come to the realization themselves and this can be guided by instructors allowing for student discovery. However, to honor and respect the community partners in service-learning, appropriate technology must be employed that benefits the partners and the instructors have an obligation to insure that is accomplished.

Lastly, selecting the right team makeup is essential. Students spoke to leaning on one another when obstacles came up. Specifically, lower level students sought help from senior level students. Therefore, as an instructor, making sure the make-up of the team contains a balance of students with senior level expertise is very important. The reflections offer regular insights into the blended experiences of the mentors and mentees. Peer evaluations are used in this course twice a semester and are valuable, but the weekly reflections offer additional formative feedback that can be used by the instructors.

Limitations and Future Work

Although the reflections provided a rich source on what students were doing and thinking, the research is limited to the point of view of the students and a single design team. Interviewing and receiving insight from the community partner's viewpoint may bring to light other aspects. The reflections were chosen as they were an authentic artifact of the course. Direct measures of technical and professional skills could be applied to triangulate the data. Interviewing the community partner to gain insight into their perspectives would add another layer to this research.

Research on other software-oriented teams would also be interesting to look at to compare and contrast how teams balance learning, implementation and community relations. This particular team also had a local community partner. Therefore, looking at teams that work with global communities would be interesting to look at in comparison to teams that work with local communities. Lastly, expanding analyses of reflections across multiple divisions to compare software teams with other engineering disciplinary focused teams would be interesting to look at as well.

Conclusion

This study provided insights into (1) how students perceived learning technical and professional skills, (2) how students perceived they were accomplishing project goals, and (3) how they perceived their relationship with the community partner including the impact of their project and the impact of the community on themselves while developing software solutions. By analyzing the students' perspectives on the team, we attempted to understand how students balance their own learning, project implementation, and community relations and impact while developing software solutions. At times, this balance proves to be difficult and therefore, as instructors, it is important we understand the innerworkings of the team in order to better help our students. We also hope this provides insight on how things are managed in a service-learning software project for other instructors who teach similar courses or who are looking to integrate service-learning software projects. Finally, the study demonstrates the effectiveness and applicability of reflection within software engineering experiences.

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