



Empathy in a Service-Learning Design Course

Nusaybah Abu-Mulaweh, PURDUE UNIVERSITY

Nusaybah Abu-Mulaweh is a Continuing Lecturer in the Engineering Projects In Community Service (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. After working as a software engineer in industry, she returned to academia as a lecturer and she is currently pursuing her PhD in Engineering Education at Purdue University in West Lafayette, Indiana.

Dr. William "Bill" C. Oakes, Purdue University at West Lafayette

William (Bill) Oakes is the Director of the EPICS Program, a 150th Anniversary Professor 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.

Paul Leidig P.E., Purdue University

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Abstract

The development and skill of empathizing with others has become a necessity for successful design engineers. To develop this skill, learning experiences are needed that encourage engineering students' understanding of their users and stakeholders. Studies have shown an "authentic" experience involving real-world contexts reflecting the work of professionals helps to develop and foster empathy. At Purdue University, a service-learning design program partners multi-disciplinary teams of students with community organizations to address needs and solve real-world problems. In previous research on the program's design process, findings showed how students perceive the human aspect of engineering design and how they empathize correlated with their relationship with their team's community partner. This study takes the research further to understand what factors specifically contribute to the manifestation of empathy. The analysis is based on the Jean Decety and Yoshiya Moriguchi model of empathy that categorizes empathy into four components: affective sharing, self-awareness, mental flexibility, and emotion regulation. Findings show clear benefits from regular interaction with the partners and differences between students who have an immersive experience with their partner in addition to their regular course experience.

Introduction

In order to effectively meet the needs of users and avoid errors, engineers need to understand their clients, users, and stakeholders. An important part of this process is empathy. By empathizing with their users, engineers design innovative solutions that focus on their needs, discover new product applications, avoid potential future mistakes, and save money and resources. Although the benefits are clear, research shows that engineering students become less empathetic over the course of their studies [1]. According to a longitudinal study conducted by Erin Cech from Rice University, engineering students rated the importance of matters that show compassion, such as wanting to improve society, being active in their communities, and helping those in need, lower after they completed their studies [1]. According to Cech, "If students are not prepared to think through issues of public welfare, then we might say they are not fully prepared to enter the engineering practice" [1]. Therefore, development and skill of empathizing with others, has become a necessity for successful future engineers.

Empathy and Engineering

When we are empathetic, our ability to receive and process information is enhanced. Therefore, this level of understanding others helps engineers design concepts and products that are both innovative and aligned to actual user needs and desires [2]. An understanding of the shift in engineering work is needed in order to identify why there is a growing need for developing empathetic engineers. According to Walther, Miller, and Kellam (2012), there has been a shift from engineering work that involves solving well-defined, technological questions to ill-defined, broad and multi-faceted issues [3]. In today's global economy, engineers need to understand the complex, socio-technical context and their role within that context. In the article, "Exploring the

Role of Empathy in Engineering Communication through a Transdisciplinary Dialogue” (2012), the authors state:

Engineers have traditionally separated themselves from their work, as this was considered appropriate when the types of problems engineers were dealing with were well structured, technological problems. Now, however there is an increasing need for a different type of engineer--one that recognizes their inherent role within these complex socio-technological systems within which they work (p 9).

Therefore, the development and skill of empathizing with others, has become a necessity for future engineers to be successful in the workplace. With this necessity comes the need to design learning experiences that encourage engineering students’ understanding of their users and stakeholders. According to a study conducted by Walther, Miller, and Kellam (2012), students need “authentic” experiences in their engineering studies to develop and foster empathy [3]. In this paper, authentic experience will be defined as experience involving real-world contexts that reflect the work of professionals.

Service-learning in Engineering

Service-learning strives to develop students into lifelong learners who are mindful of their communities and the world around them by developing their critical thinking capabilities and helping them acquire knowledge to aid them in understanding the world. Service-learning has been shown to develop both technical and the broad professional skills needed in today’s global economy [4]. Implementation of service-learning varies a great deal within and outside of the curriculum. Much of the service-learning in higher education has been placement-based experiences where students spend a set number of hours in the community. In engineering, the service-learning experience is more typically project-based where students develop a project that adds value to the community partner. For example, the Engineering Projects in Community Service (EPICS) program at Purdue University offers courses that emulate industry by having multi-disciplinary teams work with a community partner to find technological solutions to human, community and environmental needs. Therefore, EPICS courses provide “authentic” experiences in which students can potentially develop empathy.

In previous research on the program’s design process, findings relating how students perceive the human aspect of engineering design and how they empathize correlated with their relationship with their team’s community partner [5]. This study takes the research further to understand how empathy is manifesting and what factors specifically contribute to the manifestation of empathy in students working on service-learning design projects with community partners varying in proximity and relationship. The paper will seek to answer one main guiding research question and two sub-questions:

1. Does the proximity and relationship with the community partner affect the manifestation of empathy in students on service-learning design projects?
 - a. How is empathy manifesting on service-learning projects?
 - b. What factors contribute to the manifestation of empathy in students working on service-learning design projects?

Context

The EPICS program engages students in long-term partnerships with local, regional and global community partners [6]. Undergraduate students from all engineering disciplines and other majors across the university earn academic credit within their respective plans of study. EPICS students create engineering-based design solutions tailored to the needs of community partners using a human-centered design process that is meant to include partners throughout the development, design and support of the projects. Partnerships are formed by the program with partners signing an MOU with EPICS to work for at least five years. The agreements cover expectations, communication and liability of delivered projects. Students register for different divisions of the course that are paired with one or more of the partners. Each section forms a large team with 8-24 students who meet for two hours each week with a graduate teaching assistant and a faculty, industry or staff advisor who serves as a mentor. The large teams are typically broken into smaller design teams of 3-6 students per team. The divisions are led by students and typically begin with each project team reporting on their progress, the issues they encountered during the week and their goals for the coming week. A leadership structure is designed with a student project manager in charge of the overall division with design leaders for each project team. The majority of the class time is spent working with the advisor(s) and TAs with individual teams. In 2019-20 there were 40 divisions and over 1100 students enrolled over the academic year.

Students are required to keep electronic design notebooks using Microsoft's OneNote as the primary repository for their work. They are required to document their weekly work and accomplishments as well as a weekly reflection. This allows instructors to access their work for formative evaluation and feedback as well as summative grading.

The weekly reflections are left open for the students to choose their topics to write on. Four general prompts are given to them for guidance, however, ultimately, students can choose whatever they want to reflect on. These prompts are based on the work of Ash, Clayton and Moses [7]

- a) Personal and Professional Development: What did you learn about who you are (your strengths, weaknesses, assumptions, skills, convictions, etc.) and who you want to become, personally or professionally?
- b) Social Impact: What did you learn about the broader impacts of your work and how you and others can affect change locally and/or globally? What did you learn about the community, the needs, and/or the quality of the service provided?
- c) Academic Enhancement: What did you learn related to your discipline and how was that enhanced by the service-learning context? What did you learn about Human-Centered Design?
- d) Ethics: What you have learned about professional ethics, the ethical issues you encountered in your team and your project, and how decisions regarding ethical issues are made individually and as a team?

The reflections offer a rich opportunity for data analysis to see what students are taking away from their experience and believe is important each week. For this study, the student reflections

were analyzed from five teams that represent local, regional and international partners to examine how these factors impacted empathy expressed through their reflections.

Methods

The weekly reflections from the Fall 2019 semester were evaluated by a team of three researchers. Students from the selected teams were purposefully sampled to include those who participated in the immersive experiences and similar students who did not. Students were selected based on those who provided quality reflections based on their evaluations to insure sufficient materials to evaluate. The gender, year and majors were selected to represent the overall team distributions.

The model by Jean Decety and Yoshiya Moriguchi [8,9] for empathy was used to understand how empathy was manifesting on the EPICS teams. According to the model, there are four components that interact to produce the experience of empathy: affective sharing, self-awareness, mental flexibility and perspective taking, and emotion regulation. We used this model's empathy components, described in Table 1, to code the weekly reflections.

Table 1: Empathy components used to code student reflections.

Component of Empathy	Explanation and Categories
Affective sharing	Reflecting on feelings of another: (1) actual mirroring of emotion, (2) having response to emotion shown by others
Self-awareness	Distinguishing self and from other's experience: (1) self-awareness in general, (2) awareness of others, (3) do they differentiate between self and other experience
Mental flexibility & perspective taking	Taking the perspective of another without eliminating a sense of self
Emotion regulation	Regulating emotions cognitively without affecting oneself: (1) regulating own emotions within self, (2) regulating own with others

The empathy model was broken into codes described and the reflections were read to look for indications of the empathy components. Three researchers reviewed the teams with each researcher taking different teams. To calibrate at the start of the coding, a student was evaluated by multiple researchers and the results compared. Following the calibration the rest of the students were coded and quotations were selected that communicated one or more categories. Each researcher used the coding criteria to select quotes and tallied which category they represented based on the model. The three researchers compared the results and shared examples to ensure consistency between coders. After the initial coding, it was determined that the reflections needed to be recoded to distinguish the subcategories as described in Table 1. After

the second round of coding, the results were compared again and the results were found to be stable.

Participants

The teams that were included in this study are found in Table 2. The teams represent different kinds of partnerships. Their location is classified as local when the team can interact directly with their partner during their class time. The students on the global teams only interact personally when they travel. Regional partnerships are like the global teams in that their partners are far enough away that a trip over several days is required.

Within each team there are differences in the student experiences. Earlier work showed that while the regular class and community experience is powerful, it can be enhanced with immersive experiences where students have extensive and direct connection with partners [10]. With the local teams, there are opportunities for students to have immersive experiences on a more regular basis. With the team A this could happen during lab time. For the B team, students would work on an entire day along with the staff as an optional experience. For the global and regional teams, these involved trips to their partner communities and were limited to a subset of the team members. Students who had participated in these immersive experiences and those who did not were sampled to explore the impact of those experiences. Students were purposefully sampled from each team representing where possible those who had the immersive experiences and similar students who did not. For team D there were no students who participated in the trip and registered for the selected semester. As seen in Table 3, each student was given a pseudonym to maintain anonymity per the protocol from the Internal Review Board.

Findings

In the next section, we present the themes resulting from a thematic analysis on weekly reflections coded using the Decety and Moriguchi model of empathy [8,9]. The findings illuminate on (1) how empathy manifests and (2) what factors attribute to the manifestation based on students' weekly reflections.

Empathy Components

The most common empathy construct found in the student reflections was the self-other awareness. Across all the teams, regardless of the community partner, most students clearly reflected a strong self-awareness and an awareness of others. However, an awareness of difference in experience between self and other was only seen in reflections from team C.

The following quote from a student's reflection on team C exemplifies this awareness:

Having anthropologists and engineers work together is necessary when working on any human-centered design project, because engineers are able to solve the problem, but anthropologists offer a crucial perspective, without which a human-centered design project would never be successful to its highest extent.

Table 2: Description of the sampled teams.

Team	Description of projects and community partner	Proximity	Relationship	Immersive Experience	Number of students
A	Developing software applications to help with communication and learning at a Deaf school. The community partner is a teacher at the Deaf school.	Local - the teacher and Deaf school is an hour away	Direct - students work directly with the teachers and Deaf students. They visited the school once and kept contact with them via email and skype.	Students visiting teams on campus and directly interacting	4
B	Design wide array of projects for local nonprofit working with families and neighborhoods	Local - in same city	Indirect - students work directly with nonprofit staff but not with recipients of their services	Saturday work days with nonprofit staff	5
C	Working with partners to design and construct a potable water catchment and distribution system in a mountainous rural community.	Global - the partner and non-profit organization is international.	Direct - students work directly with the community members. They visited the community twice and kept contact with them via messaging software.	Travel to community	6
D	Developing electro-mechanical devices to help deaf individuals with on the job tasks. The community partner is the co-founder of a non-profit organization that hires Deaf employees.	Global - the partner and non-profit organization is international.	Indirect - students had contact with the co-founder of the non-profit, however no contact with the Deaf community. They did not visit the site, and kept contact via email and facetime.	Travel to community	3
E	Developing designs for infrastructure to address food sovereignty and cultural education	Regional - partner is a tribal college and native tribe	Direct - working directly with representatives from the tribe	Travel to community	6

Table 3: Students on the sampled teams.

Pseudo	Gender	School Year	Major	Team	Immersive Experience
Jessica	F	2nd	Spec. Edu	A	yes
Carolina	F	2nd	Spec. Edu	A	yes
Carlos	M	1st	1st Yr. Engr	A	yes
Jon	M	1st	1st Yr. Engr	A	yes
Abhi	M	1st	1st Yr. Engr	D	no
Bob	M	1st	MechTech	D	no
Sophia	F	1st	1st Yr. Engr	D	no
Sue	F	3rd	Mech Engr	C	no
Liz	F	4th	Envir. Engr.	C	yes
Karen	F	3rd	Mech Engr	C	yes
Kristen	F	3rd	Bio Engr	C	yes
Alyssa	F	3rd	Bio Engr	C	no
Haley	F	3rd	Civil Engr	C	no
Aditya	F	1st	1st Yr. Engr	B	yes
Andy	M	1st	1st Yr. Engr	B	yes
Pam	F	1st	1st Yr. Engr	B	yes
Mary	F	4th	Inter Disc Engr	B	no
Josh	M	1st	1st Yr. Engr	B	no
Karl	M	3rd	Trans Disc Tech.	E	no
Ellen	F	1st	1st Yr. Engr	E	no
Clare	M	1st	1st Yr. Engr	E	no
Amanda	F	4th	Civil Engr	E	yes
Phil	M	3rd	Civil Engr	E	yes
Pat	F	3rd	Aero. Engr	E	yes

The student differentiates between the experience and knowledge between engineers (this includes themselves) and anthropologists, and how these differences in experience and knowledge are not only beneficial, but also essential for the success of the team. Examples where students illustrate self-awareness or awareness of other include the following quotes:

I learned that I really want to improve myself in all professional aspects, especially communication skills as there were times during design reviews and [community partner] visits where I would have liked to converse with more stakeholders/volunteers to build

rapport if nothing else but ended up struggling and not being as effective as I wanted to. All of these experiences made me learn that although I do have some skills, every aspect of them can and should be improved in order to be a successful engineer and well rounded person.

In this quote, a student on team B is aware of their own skill set and what they need to improve on. This first example illustrates self-awareness, while this second example illustrates awareness of others. A student from team E reflects:

Throughout this semester I have learned how hard the [community partner] people have fought to maintain their culture, how hard they've worked to make sure it thrives. Before this class, I had not had an opportunity to work with any Native American tribes, so all I knew about their struggles was based in the past and what few current news articles have been written in their support. One of the main purposes of this project is to create affordable and sustainable housing. Some families are living with 10+ people in a single or two bedroom home, and throughout this semester it has become clear to me that to do nothing to help them would be immoral. With the help of the vocational team, or I should say the vocational team with a bit of help from us wants to fix this problem. And I have been extremely lucky to be apart of it.

The student reflects on the community and their struggles, and therefore, exemplifies an awareness of others.

Although the highest number of empathy findings came from self-other awareness, we found eight instances where the students exemplified emotion regulation and four instances where students exemplified affective sharing.

For emotion regulation, we found that most students would discuss how they regulated their own emotions within themselves, however, none of the instances found exemplified regulation of their emotions with others. Also, the instances found came from students on all teams except team A. Here is an example of a student exemplifying emotion regulation:

This final week leading up to mid-semester design review was very stressful because everything had to come to a pausing point with results. Meanwhile, I had three exams and other projects, so this was an important week of recognizing how to balance my responsibilities in all my classes, extra-curriculars, jobs, and research. Just because everything comes to a head at once does not mean certain things should fall below as less important. At the end of the day, I chose to put all these things on my plate because they are meaningful to me and my growth as a student, engineer, and person.

This quote shows how a student on team C tries to regulate stress with a sense of meaning. Therefore, they are regulating their own emotions within themselves.

For affective sharing, we found four instances on teams A and C. For all of the instances, the students had a response to an emotion shown by others, however, there were no instances of actual mirroring of emotion. Here is an example from a student on team A:

I could definitely see her passion and effort to defend her ideas and dreams. She dove into an area where the chances of succeeding were minimal, and her determination paid off. She is definitely an inspiration to me and I will do my best throughout the time we work together in order to help her continue to thrive.

In this quote, the student is inspired by their community partners passion and commitment.

For the perspective taking and mental flexibility empathy construct, we found one instance on team C. The student states, “This story was captivating, as I have never felt so close to understanding what it might feel like to have a decision like that on my shoulders”. The student imagines what it would be like in another's position, and therefore, is taking their perspective. Although this was the only clear example that met the criteria for perspective taking and mental flexibility, we found some instances where students came very close to perspective taking.

Factors for Empathy

We found five different factors that attributed to the manifestation of empathy seen in the student reflections. They included

1. Self-driven
2. Community partner(s) - this included community partners, the community as a whole, and the immersive experience with the partnered community
3. EPICS mentors - this included advisors, teaching assistants, and design reviewers
4. Teammates - this included students working on the same project/team
5. Others - this included any other factor that did not fit into the other categories.

There was no apparent connection between the factors and the team type or community partner. The factors were seen across all team types and community partners.

Immersive Experience Impact

The factors that triggered empathy in the student reflections varied across the teams, however, we found that the immersive experience of meeting and interacting with their community partner and community as a whole at the community site was usually the setting in which empathy was triggered. Interestingly, even students who did not participate in an immersive experience had knowledge from this experience through current or past teammates or even EPICS mentors who did.

The differences within the teams with subsets having the immersive experiences was not as pronounced as expected based on the categories in the empathy model. Differences were clear however. An example is from Team B when Pam shared:

We took a trip to volunteer at [the nonprofit] on Saturday. We meet one of the construction managers named [omitted]. He told us that he joined [the nonprofit] after he had a rough part of his life. He said that (it) offered him a second chance and he could

give back to his community. Plus, (it) allows troubled teens to volunteer with them during the week, and he said he was able to relate to their struggles and help with more than just building houses. This story that he shared with us showed me how great of a program (the nonprofit) really is. It gives people who work there a second chance at life, while also providing homes for people who need it.

By the coding scheme this fits into awareness of others and she did not explicitly indicate how she took the perspective of the partner, but she showed significant awareness of the partner and the larger context in which the work was being done. She added, “This is part of the reason I wanted to be part of this EPICS team, so I could help out (the nonprofit’s) mission and help improve the lives of others”.

These deeper insights into the partner were not present in those who did not have the immersive Saturday at the partner. A question is if the immersive experience itself was the factor that led to this deeper thinking or if the student came with more empathy. The week before the Saturday experience she had written:

We visited our community partners at (the nonprofit). While visiting, we passed through the neighborhood and got to see all the paintings that had been painted onto the buildings. (They) had actually helped sponsor that project of improving the neighborhood and it was amazing to see what impact it had. Just a few paintings totally transformed the neighborhood into a desirable place to visit and take pictures of. By seeing what impact (they) could have on this neighborhood, it made me realize that the projects everyone is doing in EPICS can have a similar or even greater impact on our surrounding communities. Our bike project is not just giving us engineering design experience, but at the same time, it is improving the lives of those around us. This is one of the things that drew me into the engineering field. I loved that engineering gave me the chance to use my math and science skills to improve lives of those around me.

On team E, Pat was one of the students who traveled to the native reservation last year. She wrote:

All of the 4 returning members have been out to South Dakota, and met our project partner(s) and saw part of the reservation, but even we have not seen how bad it can be, the things that (our partner) and his son have seen and experienced.

She shows awareness of the partner and also how her experience does not give her a full understanding of the conditions on the reservation. She wrote:

I think it would also be beneficial for the team to sit down and have a discussion about the reservation. Every semester we see the numbers, the statistics, but there isn't emotion attached to those. We should read some articles and talk about things that we've talked about during lab in the past, and things that Jim has told us. One thing we could talk about is the flooding that the reservation experienced in the spring. That was something very memorable, and I remember reading about how people had to be rescued on horseback, and a state of emergency was announced. One thing that came up in lab that I

think is important to note is the fact that although the team doesn't have the expertise needed to help them, we can't just walk away.

She shows a deeper understanding of the partner but like the previous example is classified under the self-awareness component of empathy of being aware of the community. She also shows that she understands that there is more for her to learn. She also demonstrates how her experience has made her more aware of the comments made during the online communication with the partner. She comments and reflects more than her classmates on what she hears about the conditions on the reservation. For example:

[Partner] talked to us about what he sees vs what his son sees on reservation. His son is a paramedic and sees the worst parts of the reservation, but [partner] works at a school and gets to see some of the best parts. He brought up how on reservation a lot of houses don't participate in the census because how they are living wouldn't be allowed for children by social services. We always talk about how poor [the reservation] is, and we visited it in May, but every once in a while a comment will be made in lab, and it still blows my mind every time.

The differences in the empathy shown as awareness of the community and their context was closer in team C. That team has a small team travel to their international partner. A difference in that team's dynamics is that there was a much more focused effort to convey the experience and lessons learned on the trip within the class and the teams. Some of the students who did not travel were working with data collected from the villagers through interviews and this gave them more insights. An interesting feature of this team is that many who did not travel were very explicit about how they knew they did not travel and there was information and experiences they did not have as a result and respected and relied on those who did.

The immersive experience does not always correlate with increased partner awareness as seen in the reflections. The project managers for Teams B and E, Phil and Andy, both showed little if any awareness of the partner's situation and context. This may be in both cases that their reflections focused on actions toward the schedules, team dynamics and obligations for the project itself.

Discussion

In the following section, we will address the research questions by discussing the manifestation of empathy and triggers found in the student reflections, and the effect of proximity and relationship of the community partner on how empathy manifests in students on service-learning design projects. We will also discuss other insights we gained from this exploratory study and what we can incorporate into the program to foster empathy development. Lastly, we will highlight the limitations of the approach and suggest areas for future research.

According to the Decety and Moriguchi model of empathy [8], the four components, affective sharing, self-awareness, mental flexibility and perspective taking, and emotion regulation, are intertwined and interact with each other to create the subjective experience of human empathy. Therefore, none of these components account exclusively for human empathy. Based on our analysis of the student reflections, we found that most students were exemplifying the self-

awareness component of empathy and only a few examples were found where students exemplified affective sharing, mental flexibility and perspective taking, and emotion regulation. However, it is important to note that these findings are coming from reflections that are guided with self-selected reflection prompts. The prompts discussed earlier in the paper ask students to talk about their personal and professional development or academic enhancement. There is a prompt that guides them to talk about the social impact their projects can have, however, none of the prompts explicitly guides them to talk about their empathic development. For future research and practice in the program, it would be interesting to see what comes up when students are asked to explicitly reflect on their empathic development.

Out of the four components, mental flexibility and perspective taking was what we saw the least in the reflections. A lot of students did come close by expressing awareness of their partner and the conditions they were addressing. However, ultimately only one student showed mental flexibility and perspective taking. Because multiple students came close, we thought about explicitly prompting students through perspective taking activities to help them express this experience in their reflections. For future research and practice, it would be interesting to see how perspective taking activities or explicit prompting about empathy would impact their reflections and empathic development.

The factors for triggering empathy were the same across all the teams we looked at. There was not a clear indication of what specifically made the most impact. However, it is clear that human interaction with their teammates, mentors, community partner(s), etc. and reflection writing help them to articulate some level of empathy. For future research, it would be interesting to see if this articulation of empathy indicates an increase in their empathic development.

As stated previously, in previous research on the program's design process, we found correlation between empathy and students' relationship with their team's community partner [5]. Through this study, we explored further to understand how proximity and relationship with the community partner affects the manifestation of empathy in students on service-learning design projects. In regards to the effects of proximity, we did not find evidence in any differences among the teams, and therefore cannot conclude that proximity with the community partner affected students' articulation of empathy. A larger impact was the frequency of interaction with the partner which did show a positive impact on the expressions of empathy. Individual differences in the richness in the reflections were evident when comparing students who had an immersive experience with the community partner(s) with students who did not. Although we did see some differences, it is not enough to clearly conclude that the immersive experience is the reason for the more empathic responses in part because the immersive experiences were voluntary. It is not clear if the experience had an impact or the students who volunteered had a higher empathy capacity. More research is needed to investigate this further.

Conclusion

This exploratory study reported on analyzed and coded weekly reflections of different teams of students to understand how empathy is manifested based on the differences in proximity and relationship with their team's community partner. Based on the analysis, findings show clear benefits from regular interaction with the partners and differences between students who had an immersive experience with their community partner. Since the immersive experiences were

voluntary, further research is necessary to conclude whether or not the immersive experience is the reason for more empathic responses. This research is important because by understanding how relationships with community partners help manifest empathy in students, instructors can better guide them in their service-learning experiences to optimize their empathy development shown to be beneficial in the development of effective engineering designers.

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