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Empathy Instruction Through the Propagation Paradigm: A Synthesis of Developer and Adopter Accounts

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ABSTRACT

Prior research indicates that empathy can help engineers achieve better outcomes in team-based, design, entrepreneurial, and humanitarian environments. We describe an educational innovation designed to teach engineering students empathic communication skills. Written in the spirit of a propagation (versus dissemination) paradigm, we focus on how the original innovation was adapted to fit into two instructional settings that differed from the first implementation context. We use first-person instructor accounts to describe these adaptation processes, including interactions between the developers and the adopters of the innovation, what modifications were necessary to "fit" the innovation into the new settings, and adopter experiences. We conclude with a brief discussion of particularly salient propagation considerations that emerged for the two adopters including, for example, the amount of instructional time available for implementing the empathic communication exercises, and how to achieve student buy-in in different course settings. The two main contributions of this paper are, first, the rich descriptions of how features of the original educational innovation had to be modified to meet the two other settings' pedagogical goals and, second, an example of how to advance scholarship that supports the propagation of engineering education teaching and learning innovations.

Key words: propagation; empathy; professional skills.

INTRODUCTION

> Engineers can become so engrossed in finding technical solutions to problems that they fail to understand, and thus neglect, the social relationships involved in projects. Building a relationship with a client requires active listening skills [and] the ability to show concern and empathy. (Hecker, 1997, p. 62)

As suggested by Hecker, the ability to establish and maintain successful professional relationships is an underappreciated and, we argue, understudied area in engineering education and practice. The goal of the educational innovation we describe in this paper is to foster a set of skills that will enable undergraduate and future engineers to build such relationships through engaging empathically with others. As conceptualized in this paper, empathic communication skills comprise a range of active listening and responding techniques that enable one to inquire into, seek to understand, and vicariously experience the thoughts, feelings, and perspectives of other people, whether those people are clients, co-workers, contractors, or members of the general public. We suggest that practicing these techniques will provide students with insight into how to form the interpersonal connections needed to collaboratively explore, frame, and solve complex socio-technical problems.

Our work to propagate this innovation sits in the context of a broader discussion around perceived gaps between engineering education research and educational practice (Froyd, Borrego, Cutler, Henderson, & Prince, 2013; Handelsman et al., 2004; Jamieson & Lohmann, 2009; Landrum, Viskupic, Shadle, & Bullock, 2017). As stated by Froyd et al. (2017, p. 35):

> Scholarly studies and national reports document failure of current efforts to achieve broad, sustained adoption of research-based instructional practices, despite compelling bodies of evidence supporting efficacy of many of these practices.

According to Froyd et al. (2017), the long-term success of an educational innovation depends both on its effectiveness (i.e., evidence base indicating impact on student development), and on its ability to be transferred, or "propagated," to other settings. The effectiveness of the innovation we describe herein has been empirically demonstrated in several prior studies (Brewer, Sochacka, Walther, & Miller, 2017; Sochacka, Youngblood, Walther, & Miller, 2020; Walther, Brewer, Sochacka, & Miller, 2020; Youngblood, Sochacka, Walther, & Miller, 2019). In this paper, we focus on how two of the original developers of the innovation (Sochacka and Walther) worked closely with two adopters (Shepard and Delaine) to propagate the innovation to two very different instructional contexts at two other institutions.

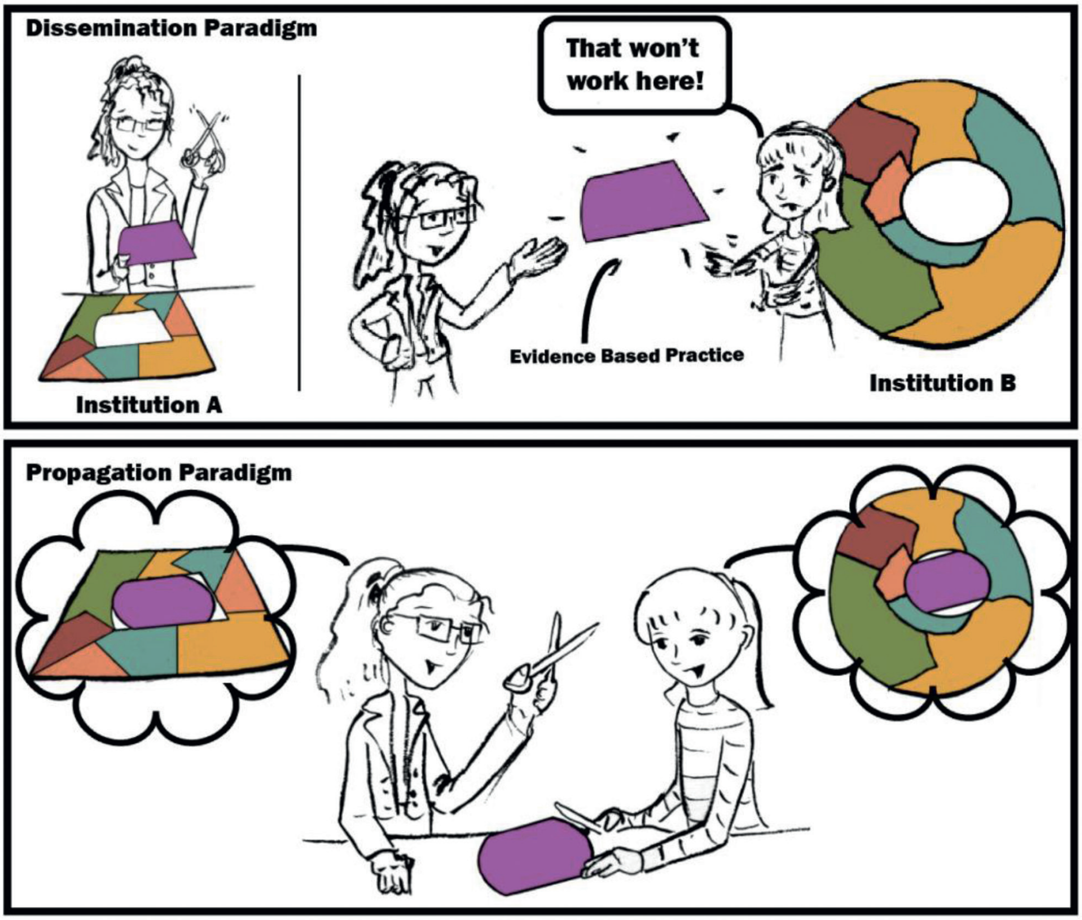

Figure 1. Original image from Froyd et al. (2017) highlighting the contrast between the dissemination and propagation paradigms.

As described by Froyd et al., the “propagation paradigm” emphasizes the systemic adoption of an educational innovation through a focus on “fit” achieved via “interacting with potential adopters throughout the development and dissemination process” (Froyd et al., 2017, p. 37). In contrast, the “dissemination paradigm” privileges evidence and raising awareness of educational innovations over their usability and widespread adoption through customization (see Figure 1).

We suggest that one way to increase the propagation of educational innovations in engineering education is to publish the results of such efforts. Doing so would have at least two distinct benefits. First, practitioners may be more motivated to engage in propagation activities if they are rewarded for their work within the traditional metrics of academic performance, e.g., journal publications. Second, writing about how educational innovations have been modified to fit into different settings will provide a broader base of practical experiences for other potentially interested adopters to draw on. Therefore, in addition to describing the specific educational innovation we present in this paper, another motivation of our work is to initiate a body of literature in engineering education dedicated to the scholarship of propagation.

We begin with a brief review of applicable literature and prior research. We then describe the education innovation in its original implementation context before detailing how the innovation was propagated to two other instructional settings. We conclude with a discussion of particularly salient propagation considerations that emerged across the three implementation contexts.

After reading this paper, we hope that engineering and other STEM educators will see opportunities to adapt our approach of teaching empathic communication to their specific settings, that is, taking into consideration "local instructional problem[s]" (Froyd et al., 2017, p. 38), course goals, grade levels, available time, teaching styles and so on.

BACKGROUND

Past research points to the importance of empathy in engineering for teamwork (Duhigg, 2016; Sheppard, Dominick, & Aronson, 2003), design (Algra & Johnston, 2015; Kouprie & Visser, 2009; Vallero & Vesilind, 2006; Zoltowski, Oakes, & Cardella, 2012), entrepreneurship (Korte, Smith, & Li, 2018), and interacting with clients (Hecker, 1997), especially clients from resource-constrained communities (Birzer & Hamilton, 2019). Research on the future of engineering similarly emphasizes the importance of empathy. For example, in a study commissioned by the Australian Council of Engineering Deans, Crosthwaite (2019, p. 27) reported that:

> specialists [from a range of fields, including engineering] will be working increasingly in cross-functional teams and higher order soft skills such as empathy, professional ethics and emotional judgment are likely to be increasingly valued. (Crosthwaite, 2019, p. 27)

This observation about the future of work aligns with Pink's (2006) discussion of the transition from what he calls the "information age," which centers on knowledge workers, to the "conceptual age," where skills such as empathy and creativity will be key to gaining a competitive advantage.

The above studies represent a small sample of the rapidly growing body of literature exploring the relevance of empathy for engineering practice. For further information on the role of empathy in engineering, we direct readers to (Hess, Beever, Strobel, & Brightman, 2017; Hess, Strobel, & Pan, 2016; Strobel, Hess, Pan, & Wachter Morris, 2013; Walther, Miller, & Sochacka, 2017).

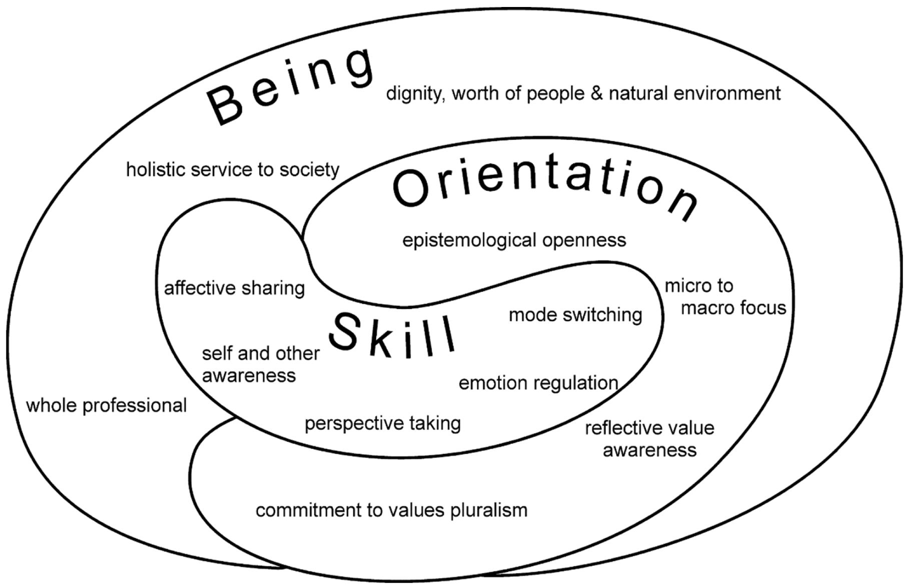

Figure 2. Conceptual model of empathy in engineering (Walther et al., 2017).

THEORETICAL FOUNDATIONS

Prior work conducted by the first and fourth authors developed a conceptual model of empathy in engineering to guide research and practice on empathy in engineering education (Figure 2). This model informed the original development and subsequent implementations of the innovation we describe in this paper.

This model defines empathy along three dimensions, each of which have different implications for teaching empathic communication skills to students. The skill dimension comprises five socio-cognitive factors that interact with each other to establish a “foundation for empathic communication, relationship building, and decision-making” (Walther et al., 2017, p. 133). For example, affective sharing describes a person’s ability to “feel with” the emotional experience of another. This phenomenon has also been described as vicarious emotional arousal and emotional contagion (Decety & Meyer, 2008) and has been linked to specific mirror neuron systems in the brain (Iacoboni, 2007).

In the empathic communication modules, students are encouraged to become more aware of and develop such skills through, in one example activity, paying close attention to, while remaining silent, the emotional dimensions of experiences that a peer shares with them, i.e., one student recounts an experience and the other listens attentively. Both students are then asked to reflect on what that experience was like for them – was the listener able to identify emotions being conveyed in the story? Did the listener notice similar (e.g., mirroring), or different, emotions in themselves? In another activity, students are provided with guidance on how to verbalize and confirm the emotions they think they are observing when their partner tells them about something of significance that has happened to them. For example, a student might say, "It sounds like you were really frustrated when X happened," after which the student who is telling their story can either confirm or correct this observation.

The orientation dimension captures a range of mental dispositions that influence how engineers, or engineering students, engage in practice situations (Brewer et al., 2017; Walther et al., 2020). For example, epistemological openness refers to the extent to which one is able to "to recognize and value the subjective experiences and perspectives of others as valid and important sources of knowledge for engineering" (Walther et al., 2017, p. 135). Someone who is not open to other ways of knowing may be less likely to effectively practice the empathic communication skills that would enable them to deeply engage with someone else's internal world, thereby missing out on the opportunity to connect with that person and learn potentially valuable perspectives on a particular situation. One approach to teaching epistemological openness as a feature of empathic communication is to select scenarios, or case studies, that involve different ways of knowing, e.g., with stakeholders from different disciplinary or cultural backgrounds. When students engage in role plays around these scenarios, they are provided with opportunities to "feel with" the people involved, both when they take on the role of different characters *and* when they take on the role of an engineer tasked with responding to someone who has a different worldview to theirs.

Finally, the professional way of being dimension highlights the need to situate empathic skills, practice orientations, and their development within a contextualizing framework of broader commitments to self, society, and the environment. This dimension tangibly links empathy to engineering ethics (Walther et al., 2017). For example, when students take on different roles and, in doing so, learn about and "feel with" different perspectives, they gain a deeper and perhaps even embodied understanding of how engineering work affects others. These experiences provide opportunities for instructors and students to reflect on larger questions around the role of engineering and engineers in society.

In the context of our propagation efforts with the two other instructional settings, the conceptual model discussed above and presented in Figure 2 helped the adopters focus on which skills, orientations, and ways of being they deemed most relevant for their instructional settings. In this way, the model provided a theoretical basis, or language, for discussions between the developers and adopters that enabled the adopters to make informed modifications to the original empathic communication exercises.

THE INNOVATION

Walther, Miller, and Sochacka used the model illustrated in Figure 2 to develop a set of 4 x 75-minute empathic communication modules that are integrated into a mandatory, sophomore-level engineering and society course in the mechanical engineering program at the University of Georgia. These modules are summarized in Table 1 and described in detail in (Walther, Miller, & Sochacka, 2016) and (Sochacka, Walther, Miller, & Youngblood, 2020). A handbook that describes these modules in detail is available for download online (http://eeti.uga.edu/wp-content/uploads/2019/02/Empathy-Modules-Workbook_2020_v3.pdf) or can be requested from the corresponding author.

In the course of pursuing traditional dissemination activities, such as publishing the conceptual model in a journal (Walther et al., 2017) and presenting the work at conferences (Brewer et al., 2017; Sochacka, 2017; Walther et al., 2016), Drs. Walther and Sochacka were approached by several faculty members who expressed an interest in adapting the modules to other teaching contexts. Two of these faculty members were Dr. Thomas Shepard from the University of St. Thomas in Saint Paul, Minnesota, and Dr. David A. Delaine from The Ohio State University in Columbus, Ohio. To facilitate propagating the original educational innovation to other instructional contexts, Sochacka worked with Shepard to adapt the innovation to a senior-level fluid mechanics course, while Walther and Sochacka collaborated with Delaine to adapt the modules to a series of community-based learning settings (i.e., service-learning, outreach, and volunteerism). The remainder of this section describes the original innovation developed at the University of Georgia and then how this innovation was adapted by Shepard and Delaine at their institutions. Each account begins with a table that provides an overview of the course setting, activities, relevant learning outcomes, and assessment, followed by a rich account of the instructor's experiences of implementing and, in the cases of Shepard and Delaine, modifying the original innovation to fit into a new context. These rich, first-person accounts are intended to provide future potential adopters with a holistic picture of what they might expect should they choose to teach empathic communication skills. Finally, we discuss insights that emerged across the three settings.

The University of Georgia

Developer perspective (Sochacka)

After facilitating the modules five times over the past five years, I have learned it is critical to make a strong case to students why empathy is a relevant skill for engineers. Without doing so, it can be challenging for students to see the relevance of participating in physical and oral communication exercises in a classroom environment typically characterized by working through numerical and equation-heavy problems. I make the case for empathy in engineering in a number of ways, such as discussing a study led by Google that identified empathy and conversational turn-taking as two of the most crucial skills contributing to team success (Duhigg, 2016). I also tell stories from my time working as an environmental engineer and how important it was to build relationships with all kinds of people, from colleagues to clients to members of the public, and how empathic communication

Table 1. An overview of the innovation implemented at the University of Georgia.

Course setting	Engineered Systems in Society, mandatory sophomore/junior course in Mechanical Engineering, 2 x 75-minute sessions per week, average section size of 40 students, multiple instructors across the course
Brief description of the innovation	4 x 75-minute modules spaced across the semester. Modules focus on: self and other awareness; emotion regulation and affective sharing; affective responding; and mode switching (see Figure 3). Students practice empathic communication skills in small groups and then apply them to an engineering scenario using role-play (see Figure 4). The engineering scenarios are typically linked to other course activities and projects. Example scenarios are the Flint, Michigan water crisis; the North Dakota Access Pipeline; the Pacific Gas and Electric (PG&E) power blackouts in California; and food security in the local Athens area.
Relevant learning outcomes, if applicable	By the end of this course, students will be able to: • Describe the primary tool used in engineering communication, i.e., the Self. • List at least five ways in which physical proximity to another person can impact the quality of communication. • Recall and practice the three core skills required for affective responding (attending, paraphrasing, and reflecting feeling). • Distinguish between, and describe the affordances and limitations of, empathic and analytic forms of communication. • Define mode-switching and recognize when it occurs in conversations. • Identify and describe three orthogonal stakeholder perspectives in a contemporary engineering case study. • Describe the epistemic beliefs and values orientations of these three stakeholders.
Assessment	Three different types of assessment have been used to evaluate student achievement of the above outcomes: after-class, prompted written reflections (completion grade, see Appendix A); in-class structured notes (completion grade, see Appendix B); and exam questions (graded on accuracy of understanding, see Appendix C).

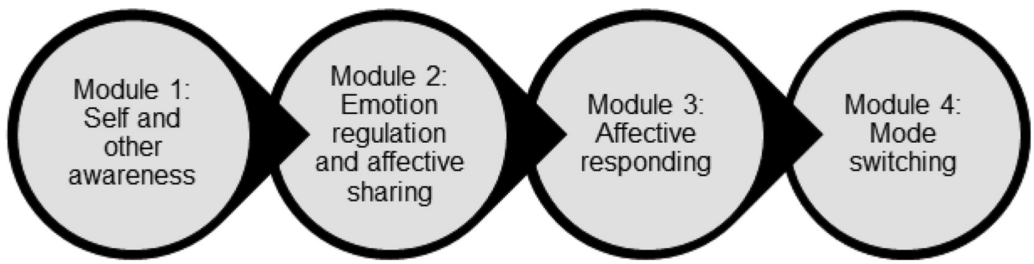

Figure 3. Sequence of four empathic communication modules over the course of one semester.

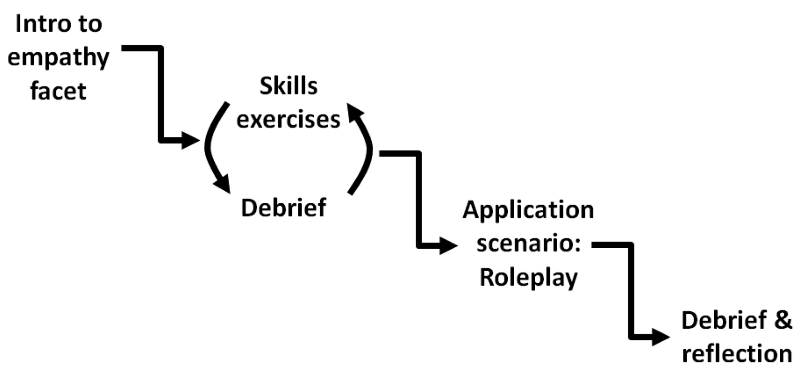

Figure 4. Overview of one module.

can help with this. Sometimes I show this video (RSA ANIMATE: The Power of Outrospection - https://www.youtube.com/watch?v=BG46IwVfSu8), which is a stop-motion, whiteboard animation that places the need for empathy in a broader societal context. I have also spoken about Dan Pink's (2006) notion of the Whole New Mind, which describes six essential aptitudes, or "senses," for career success in the 21st-century, of which empathy is one; the others are design, story, symphony, play, and meaning.

When I first started teaching the modules, quite a few students found the skill building activities (see Figure 4) a little awkward. As I have become a more confident and skilled facilitator, I have noticed that many if not most students are now happy to engage with the activities and appreciate the opportunity to develop their communication skills (Walther et al., 2020). I have even had a student tell me that one of their parents is an engineer and that their company brings in people to teach these kinds of skills.

The role plays can sometimes be challenging, I think, because role play is not a form of learning that many engineering students are used to. That said, I have been encouraged by how many students seem to appreciate the opportunity to experiment and express themselves differently in class. The first time I facilitated the role plays, I simply implored students to "run with it." I emphasized that role play works best when participants give it their all. After discussing role-play facilitation in more depth with Dr. Shari Miller, our colleague from the UGA School of Social Work and collaborator in the initial development, I began to more explicitly lay out the affordances of this type of activity, e.g., a low-stakes environment to try out different communication techniques, opportunity to try on other perspectives, space to *feel* what it's like to be an engineer. I found that this transparency helped a lot with buy-in. The last time I facilitated the modules, I went one step further. I asked my class if someone had participated in a role play before, either at university or in high school. I then asked those students who had to describe the benefits they had experienced. I was pleasantly surprised to observe that this approach led to a discussion of most, if not all of, the benefits of role plays I used to lay out in previous years.

I have found that the modules, particularly the role plays, have also improved since we started tying them to engineering case studies we examine in class. In some years, my colleagues and I have asked student teams to develop character vignettes for three to five key stakeholders as a first team project. We then use these vignettes in the role plays.

In addition, I endeavor to connect the modules to other parts of the class as much as possible. For example, early on in the class we read a paper by Jonassen, Strobel, and Lee (2006), which calls for a greater focus in undergraduate engineering programs on communication, among other aspects. I also have students do a mini-design project on the first day of class, in which they invariably jump to the technical details without considering client needs and other social aspects of the problem. I refer back to these readings and experiences as anchor points to ensure that the modules are integrated with the overall arc of the course.

Finally, it has been interesting to observe how the modules have changed the way I approach teaching. In order to facilitate the modules effectively, I need to model empathic communication, which means that I need to be curious about and attuned to student perspectives, feelings, needs, and experiences. This attention has led me to step away from strict attendance policies. It has increased my awareness of the economic needs of different students and focused my attention on what it might be like to be the only woman or African American in the classroom. Practicing empathic communication with my colleagues, and even with my friends and family, has also given me a deep appreciation of both how challenging and important it can be to develop these skills.

University of St. Thomas

Adopter perspective (Shepard)

I first learned of surprising research pertaining to undergraduate engineers when listening to Dr. Sochacka at a workshop. Evidence shows engineering undergraduates' interest in public welfare, social consciousness, and empathic thinking decreases as they progress towards graduation (Cech, 2014). Since I teach engineering undergraduates, this is alarming, as I would not want this for our students. Armed with this information, and an internal KEEN grant, I embarked upon creating a small intervention for my fluid mechanics class.

The process of finalizing my module and student activities was informed by the articles I had read and, to a larger extent, communication with Dr. Sochacka, who co-authored some of those articles. Dr. Sochacka graciously shared materials she helped develop for UGA courses. While my result was different, having access to those materials was useful in contemplating the different

Table 2. An overview of the innovation implemented at the University of St. Thomas.

Course setting	Fluid Mechanics, mandatory junior/senior level course in mechanical engineering, 3 x 65-minute lectures per week, 1 x 2-hour lab per week, sections of 36-49 students
Brief description of the adapted innovationo	Using a 30-minute in-class lesson, students are presented with the motivation for why engineers should care about using empathy in their profession. The difference between empathy and sympathy, and the difference between empathic and analytical thinking, are presented via examples. Students are instructed on mode switching and how one can respond to another person in a way that demonstrates empathy through reflective feeling and paraphrasing. Students then work in small groups to craft an empathic response to a real-life scenario presented by the instructor.
Relevant learning outcomes, if applicable	After completing these activities, students will be able to: • Identify difference between sympathy and empathy. • Recognize why including an empathic response to another person can be more beneficial than simply an analytical response. • Demonstrate empathy in a response by paraphrasing and reflecting the feelings of the other person. • Gain a better understanding of professional and ethical responsibilities of engineers.
Assessment	Students completed a homework assignment with a real-world engineering scenario where students were asked to identify stakeholders, describe how the people in the scenario might be feeling, and craft both empathic and non-empathic responses (~2–3 pages; see Appendix D.

manners in which the topic of empathy could be used in an engineering context. I also spoke with Dr. Sochacka on the phone as the objectives of my empathy module and the form of my assignment became clearer. She provided helpful suggestions and critical feedback that greatly improved the lecture content I would deliver as well as the questions and format of the assignment. For example, she shared PowerPoint presentations from which I adapted a couple of slides that fit the goals of my lesson. Perhaps as importantly, she shared her great enthusiasm for what I was doing and how I was doing it. Developing something new can be daunting, particularly when it is a bit outside one's area of expertise. Her support provided momentum for staying on target and allowed my lesson to remain authentic to my teaching style and priorities.

Frankly, before my first time leading the empathy lesson, I was nervous about student buy-in. This would be a major detour from the course subject material (fluid mechanics) in order to deliver a lesson on empathy to mostly senior-level students. I feared that students would see this as an unnecessary departure from technical material that could help them be stronger engineers. I was worried that they would see this as a professor imposing some half-thought-out idea on "soft skills" that would take time, be awkward, and not really lead to any useful outcome. I addressed those concerns head-on and acknowledged that some of the students might be a bit worried. I assured them the lesson and assignment would not be very time consuming, would actually slow the pace of the technical fluid mechanics content giving it more time to sink in, and would likely be a much more important lesson than an extra 30 minutes on fluid mechanics. I explained the motivation for the lesson while citing sources (i.e., it's not just my crazy idea, this is backed up by data). Many of the sources were provided by Dr. Sochacka. The motivation can be summarized as:

- Engineering undergraduates have reduced interest in public welfare, social consciousness, and empathic thinking as they progress towards graduation (Cech, 2014).
- Google found the best technical teams were not made up of the best technical aptitude but members with the best social sensitivity (of which empathy plays a big role) (Duhigg, 2016).
- Social skills are increasingly valuable to employers (Deming, 2017).
- Your brain cannot think analytically and empathically at the same time. In engineering we only focus on analytical skills so this can become your default mode (Jack et al., 2013; Paddock, 2012). We need to recognize that empathic thinking has a role in engineering.
- Your engineering education is focused almost solely on technical content, so we are not adequately preparing you to be an effective engineer with that focus.

With these arguments as the lead in, I appeared to have excellent buy-in from the students as evidenced by their attention to the lesson and feedback on the assignment. The lesson aimed at demonstrating the importance of mode-switching, that is, alternating between an analytical mode of thinking and an empathic mode. This included some short videos, such as this one by Brené Brown (Brené Brown on Empathy: https://www.youtube.com/watch?v=1Evwgu369Jw) and this one by Lifehacker (The Importance of Empathy: https://www.youtube.com/watch?v=UzPMMSKfKZQ), a brief lecture, and students practicing crafting empathic and non-empathic responses. A review of the assignments showed excellent student acknowledgment of the importance of empathy for engineers and a strong ability to craft empathic responses, at least when given time to do so. Briefly, some of the insights I gained as instructor are:

- Avoid a judgmental tone about reduction in student empathy, but explain how the curriculum is largely to blame and, if relevant, acknowledge your own struggles with switching out of the analytic mode of thinking (I literally said “my poor wife” in reference to my own inability to get out of the analytic mode of thinking).
- Scenarios presented to a student are better received when coming from a real-life experience. I asked many of the engineering faculty and colleagues in industry for example scenarios – most had a story that they really wanted to share!
- Students with experience working in retail or service jobs proved good at constructing empathic responses and relating to people described in the scenarios.
- Many female students commented along the lines of appreciating the lesson and assignment for showing that there was a place for their way of thinking in engineering.

I have given the empathy lesson seven times now based on how well it went the first time. Instead of being nervous about buy-in, I am now excited for the students to participate. Had the first experience not gone well, I would have been far less likely to repeat the lesson. Without the assistance of Dr. Sochacka helping to propagate all that she had learned from her efforts, many students may have missed out on instruction with empathy in an engineering context.

The Ohio State University

Adopter perspective (Delaine)

I am leading NSF-funded research that investigates the development of empathy in engineering through community-based learning (CBL; i.e., service-learning, outreach, and volunteerism, Delaine & Walther, 2018). As part of this work, my research team and I have adapted the original empathic communication modules to five different CBL contexts. These contexts, each of which involves interaction with non-university members from the community, range from for-credit service-learning and humanitarian engineering courses to brief volunteering activities for engineering students. This adaptation process has involved regular interactions with Walther, who is a co-PI on the NSF research, and Sochacka. Following several virtual conversations, Walther and Sochacka set aside

Table 3. An overview of the innovation implemented at The Ohio State University.

Course setting	As part of NSF-funded research (Delaine & Walther, 2018), five different community-based learning (CBL) cases were enhanced to include instruction on empathy in engineering via adapted modules. These included one full-semester, for-credit service-learning courses; two co-curricular activities for humanitarian engineering; and two, non-credit-bearing volunteer activities. Each case revolved around interactions with non-university community members. The assets and needs of each "community" population were highlighted for role plays and vignettes.
Brief description of the adapted innovation	For example, one of the CBL activities was a volunteer activity in which undergraduate engineering students support children with special needs by adapting toys at a local hospital. An hour-long training session was added to the 4-5-hour volunteer session to prepare the students for positive interactions with the children and families while adapting the toys in the volunteer session. Fifteen minutes of the hour-long training covered logistics and set the stage for the engineering-focused intervention. Instruction of empathy took place in the remaining 45 minutes where students practiced skills in small groups. A debrief discussion supported understanding of how the scenarios could play out during the volunteering session.
Relevant learning outcomes, if applicable	By the end of the training session, students were to be aware of: • Empathic communication skills including: self and other awareness; emotion regulation and affective sharing; affective responding. Mode switching was not focused on as a skill but highlighted as a component to be recognized. • CBL is an important developmental platform for strengthening professional skills in addition to making contributions to society. By the end of the volunteer activity, students were to: • Recognize how empathic communication is relevant to engineering and CBL contexts and appreciate the value of empathy in engineering.
Assessment	From within each activity, assessments of the modules implemented by the instructors were limited. One case included a rubric element that evaluated the student projects via an item that reviewed how projects "incorporated empathy concepts," rated from 0 - missing to 5 - excellent. Assessment was included within the research; three different types of assessment have been used: pre-/post-module quantitative survey using the modified IRI (Hess, Chase, Fore, & Sorge, 2018); 60-minute focus-group session with 4-6 student participants to capture broad phenomena and opportunities for empathy in CBL; and 60-minute interviews with a single student purposefully sampled from the focus group to capture in-depth interpretations of the experience.

a morning at an engineering education conference to train two graduate students and me on how to facilitate the original modules. We took several hours to work through and debrief two of the four modules. Walther, Sochacka, the graduate students, and I took turns facilitating the modules and participating in the activities to help clarify how we could adapt the modules to CBL contexts. I recall feeling impacted by the modules and saying to myself, "Wow, I thought I was a good communicator, but clearly I have a lot to learn." This experience allowed us to understand the structure and outcomes of the modules as well as to consider what our students might experience when we instruct them. It also helped me more deeply understand the model of empathy in engineering and more concretely understand the role empathy plays in this context.

Over the next few months, we continued to prepare and bounce ideas off Walther and Sochacka. Using the module workbook as a frame of reference (Sochacka et al., 2020), my research team adapted the modules to five CBL settings. My team did not design or establish the CBL activities, but we supplemented each to include empathy in one or more learning outcomes. For each CBL setting, we held several meetings with the CBL activity instructors to 1) discuss the empathic communication modules used by the developers (i.e., learning outcomes, activities, debrief); 2) determine what elements of the modules aligned with each CBL context; and 3) work out how the original modules would best be adapted. Our research team used these negotiations to develop the approach and outcomes of the modules to be used in each CBL context. For example, the CBL activities were often brief in duration, so we could not implement the 4 x 75-minute modules or include all learning outcomes used by the developers. In all cases, we decided to implement the instruction prior to the student interactions with community members.

In four out of five cases, we implemented the proximity exercise as the first activity, considering it a great way to initiate active learning and teach self-awareness. (I.e., students stand 8-ft away from each other. One student walks toward the other, stopping when they begin to feel uncomfortable.) In the debrief sessions, several of the students suggested that they had no hesitation with the activity and that it did not feel awkward for their classmates to approach right up in front of their noses. As the instructor, I then asked if a community member from the CBL activity were to do this, what would happen to their comfort level? This question seemed to bring the activity into a better light for the students, suggesting that the positionality of those being communicated with is important to consider in the use of these modules and highlighting a strength of leveraging CBL for empathy in engineering.

We had initially thought it would be easy to link the modules to the CBL context of our instruction to highlight the value of empathy in engineering. As we worked to adapt the modules, however, we found this to be more difficult than we had anticipated. For example, in one of the CBL settings, where students were designing shelters for home-insecure individuals, it was challenging to generate examples that linked empathy to better engineered solutions. We spoke with Walther, who offered several examples relatively quickly. It appeared that his experience with the modules and research in the space provided him fluency. This instance highlighted to me the importance of working with instructors who have prior experience with the modules.

We reflected on two ethical dilemmas of implementing the modules within the community-based settings. First, we debated whether role playing would be appropriate for the selected CBL settings. Because, in some cases, stakeholders included the home-insecure, children with disabilities, and people from underserved communities of color, it was unclear whether perceived power differences between a college student and these stakeholders may lead to the use of jokes or stereotypes or reinforce notions of social hierarchies. After discussions with Walther and Sochacka, we found a compromise by using limited role plays based on vignettes. We then sought input from the CBL instructors and community partners for developing authentic vignettes, and we strongly encouraged the class to take the role plays seriously. Second, we were concerned about overly sensitizing the students to interactions with community members. In one of our contexts, students visit a center that supports non-communicative, elderly individuals with profound disabilities. We determined we should not over-sensitize the students to others' emotions or promote hyper self-awareness before interactions that can be very intense for those less familiar with working in these settings. We worried that over-sensitizing the students might overwhelm them and negatively impact their development of empathy. For example, if students were to proactively attempt to "feel with" the differently-abled community members through deep self- and other-awareness, yet not fully understand or have the ability to regulate emotions, this may cause challenges and prevent them from pursuing empathic connections in future CBL or engineering contexts. As a result, we were selective about which aspects of the modules to include in each case.

After we finished the instruction within each of the cases in our research, our debrief with the instructors was very positive. Several of the instructors indicated that they wanted to continue to work on supporting the integration of empathy as a learning outcome in their CBL activities. This outcome perhaps points to a shift in the propagation paradigm where I am no longer serving as the adopter but have grown into the role of developer.

KEY INSIGHTS

Earlier, we stated our intention to write this paper in the spirit of a propagation paradigm, which emphasizes the systemic adoption of an educational innovation through a focus on "fit," achieved via "interacting with potential adopters throughout the development and dissemination process" (Froyd et al., 2017, p. 37). Here we return to and modify Figure 1 to highlight which features of the original innovation had to be considered to achieve an appropriate fit with the other instructional settings (see revised Figure 5).

Table 4 summarizes six aspects that emerged as crucial to the adopter experiences described above by Shepard and Delaine.

Of the six aspects discussed in Table 1, bidirectional learning was arguably the most rewarding for the team of developers and adopters. For example, when Sochacka learned that Shepard had asked engineering faculty and colleagues in industry for example scenarios to use with his empathy activities, she also began asking colleagues at her institution for empathy-relevant examples. One of these scenarios has already been included in the empathy handbook available here (http://eeti.uga.edu/wp-content/uploads/2019/02/Empathy-Modules-Workbook_2020_v3.pdf). Working with Delaine and Shepard also expanded Sochacka and Walther's understanding of the scope of settings in which empathy could be integrated into engineering education. Before working with Shepard, they had not imagined teaching empathic communication skills in an engineering fundamentals class.

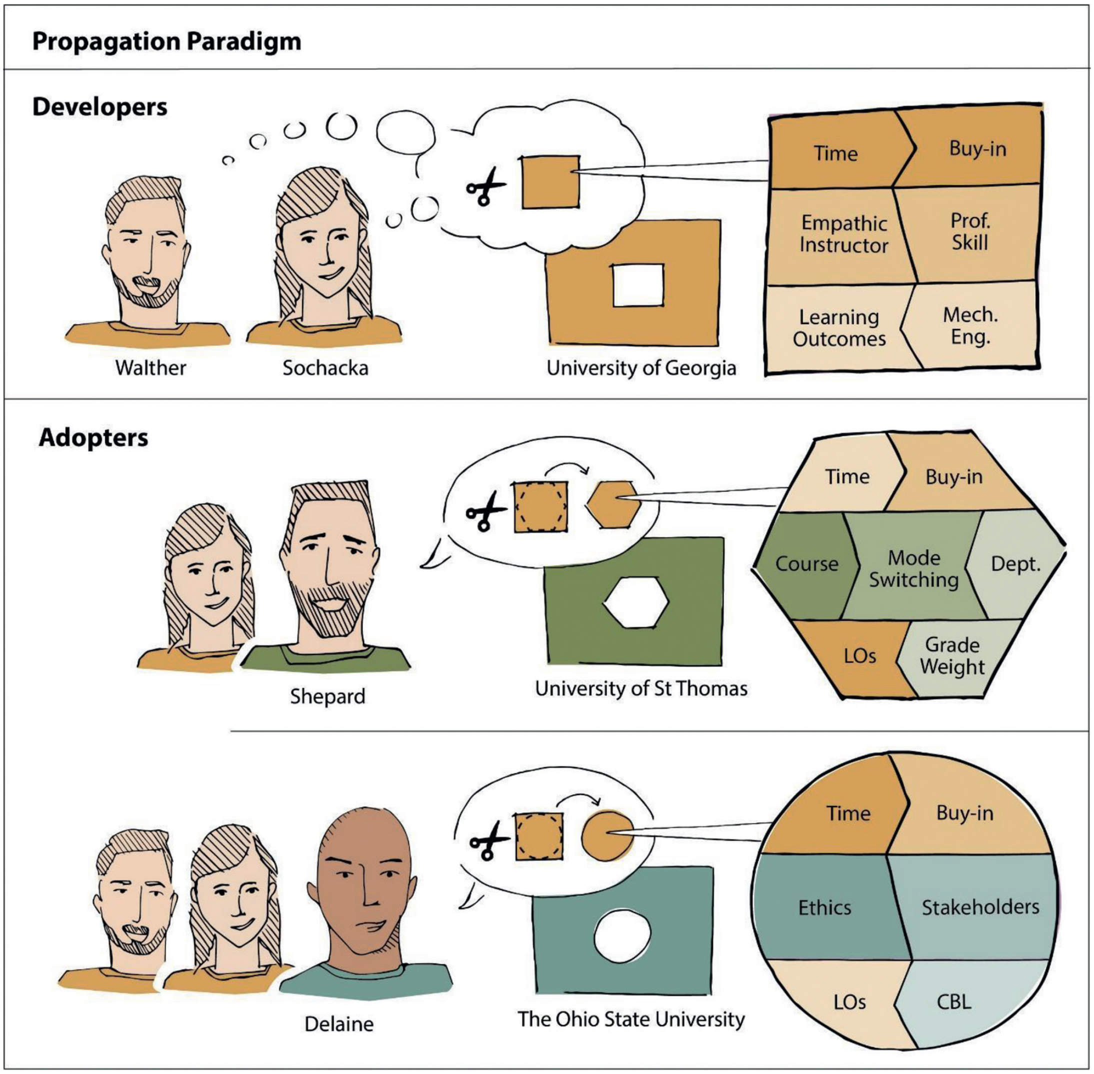

Figure 5. The instruction of empathy in the propagation paradigm at two institutions through interactions between developers and adopters.

Similarly, working with Delaine demonstrated to them what empathy-related learning outcomes can be achieved in relatively short periods of time (e.g., 15 minutes), as compared to their process of introducing empathy to students over the course of 4 x 75 minute, in-class sessions. In these ways, propagating the original innovation served to enrich both developer and adopter understandings of teaching empathy to engineering students and, perhaps most importantly, significantly contributed to expanding both the community of practitioners and scope of activities to inform future, empathy-in-engineering propagation efforts.

Table 4. Central aspects considered when adapting the educational innovation to other contexts.

Adoption Considerations	Impact	Key questions
The course setting or **context**.	Scenarios, role plays, and debrief discussions are most powerful when they are purposefully integrated with the course / instructional setting.	What features of the new context are most relevant for the development of empathic communication skills? E.g., interacting with clients? Making ethical decisions? Working effectively on a team? Communicating with the public? (See theoretical model in Figure 2)
The amount of **time** available to dedicate to the new material.	Determines the extent to which empathic communication skills can be explored, how the activities are designed, and amount of debrief discussions.	With the above in mind, which activities from the original innovation might best achieve the goals of the new setting in the time available? Which activities need to be adapted because of time constraints? How could theory inform the development of new activities?
Development and assessment of **learning outcomes**.	Clear learning outcomes serve to focus the adaptation process. The four modules and associated learning outcomes from the original innovation may not be relevant for all settings.	Building on the context and time considerations above, what are the desired learning outcomes? (Refer again to the theoretical model.) Which of these learning outcomes are assessable through traditional means, e.g., exam questions or written assignments, and which outcomes may be better suited to developmental approaches, such as engagement as evidenced through reflection?
The extent to which students "**buy-into**" the argument that empathy plays a role in engineering.	Students may have varying degrees of receptiveness to engaging with empathic communication activities as part of their engineering education. Addressing this potential issue head-on in a way that is authentic to the instructor and to the course is an important step in facilitating the modules.	How might your students react to the empathic communication exercises? For example, a class of first year mechanical engineers might respond differently than a fourth-year class of industrial engineers (the latter of which may have a greater appreciation of the role that learning about diverse perspectives plays in the engineering design process). What information, evidence, or practice-based stories can you provide to achieve student buy-in?
Support from the developers	Support from developers should enhance, and not place limitations on, the adaptation of the innovation. Different adopters will need / ask for different levels of support.	For adopters: what type of support do you desire/ need? What is the most effective/ efficient way for you to receive this support? e.g., reading previous work, an email exchange, a Zoom call. For developers: What ready-made resources can you prepare to facilitate the propagation of your educational innovation? To what extent do you wish to engage with potential adopters? What are ways you can connect to potential, future adopters / adapters of your work?
Bidirectional learning	Propagation is not a one-way, transactional process, i.e., from developers to adopters.	What assumptions do the developers hold about the affordances and limitations of the innovation? Which of these are challenged by propagating the innovation to a different setting? What opportunities exist for lessons-learned during propagation to enrich the developers own implementation of the innovation?

CLOSING REMARKS

At heart, the propagation paradigm lays out a way of thinking and a set of values that is intended to bridge the gap between research and practice. Within such a paradigm, instructors are encouraged and supported to adapt an instructional product to fit with their specific context, while achieving desired student outcomes and feeling authentic to that instructor's approach. As described by Stanford et al. (2016) and further elaborated on at www.increasetheimpact.com, the bridge to these end products can be supported by multiple elements:

- Interactive development between developers and adopters to combine their knowledge and experience with feedback on the adopter's motivations and constraints
- Interactive dissemination, which extends beyond traditional publications to further engage prospective adopters via additional strategies such as workshops, conference booths, personal connections, etc.
- Varied sources of support for the adopter provided by the developer or externally such as materials, websites, learning communities, etc.

The propagation of the innovation described in this paper leveraged all three of these approaches.

We conclude by returning to what we judge to be the two most important contributions of this paper. First, after reading the developer and two adopter accounts, and reviewing the key insights described above, we hope that some readers will feel motivated and confident to adapt the innovation described in this paper to their instructional setting. We hope that this paper, written primarily as first-person accounts of real experiences and developer-adopter interactions, has reduced some barriers to adoption, including expanding the circle of expertise that readers can draw upon. For example, perhaps an instructor who teaches a technical course, like fluid mechanics, will feel more comfortable reaching out to Shepard rather than the original developers. Likewise, it might make more sense for instructors in community-based learning settings to reach out to Delaine. At this point, we would also like to emphasize that all authors are more than happy to share our materials and lessons-learned with any instructor who is interested in continuing the propagation of empathic communication exercises in engineering education.

Second, we hope that this paper will serve as an example of how scholarship can support the propagation of engineering education teaching and learning innovations. Traditionally, researchers are expected to conduct and disseminate research. Until now, we suggest that propagation has not lent itself as easily to the reward structures associated with these research practices, i.e., funding and publications. We wrote this paper to help promote the propagation paradigm as an important complement to the dissemination paradigm and to demonstrate how propagation can be recognized through traditional academic metrics. It is important to mention that, in doing so, we also arrived at specific, i.e., empathy-related, and more generalizable contributions to the emerging body of knowledge relating to propagation (see *Key Insights* section above). We call on the engineering education community to think about other ways to incentivize propagation efforts and, through these efforts, continue to bridge gaps between engineering education research and practice.

CONTINUED PROPAGATION

We offer the description of the two propagation cases in this article as a starting point for an ongoing process that explores other application contexts of empathy learning in engineering and addresses some of the questions that may remain unanswered in this first propagation step. To suggest some directions for future propagation, we are currently supporting further adaptation of the empathy exercises in three other implementation settings. Dr. Sally Male at the University of Western Australia is implementing empathic communication exercises in a large (approximately 400 students), first-year engineering course in sections of up to 24 students. She began her first implementation in the beginning of 2020 and, due to the impacts of COVID-19, was forced to finish that implementation in an online format. Dr. Eric Schearer at Cleveland State University is using empathy as a way for undergraduate students in a general education class on disability and assistive technology to more productively engage with people with disabilities. Finally, Dr. Julia Thompson at the University of San Francisco is integrating empathic communication exercises into an Engineering in Society course, which is a prerequisite for a summer immersion program. Students will learn empathy skills and write up their personal philosophies on community engagement, before spending three weeks working directly with a community. These examples of ongoing adaptations highlight the further potential of empathy work in engineering and identify propagation of such an innovation as a living process of adaptation, mutual learning, and the building of personal connections.

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APPENDIX A: AFTER-CLASS, PROMPTED WRITTEN REFLECTIONS FOR THE ORIGINAL INNOVATION AT THE UNIVERSITY OF GEORGIA

Reflection prompt for Module 1

Today you participated in exercises about **encountering others**.

1. What were your experiences? What was challenging or enjoyable?
2. In what ways do you think these kinds of exercises are important/relevant for your personal development and for your future as a professional engineer?
3. Based on your prior knowledge and experiences and what you did in class today, what is your understanding of empathy and the role of empathic communication in engineering practice?

You are not limited to just answering these questions in your reflection. Please include any other thoughts and feelings you think are important.

Submit your reflection (about two pages) as a PDF file on eLC by Sunday at 5pm.

Reflection prompt for Module 2

Today you participated in exercises about **self and other awareness** and **affective sharing**.

1. Describe your feelings during the body proximity exercises. Why do you think you felt this way?
2. What was your experience as the engineer or stakeholder during the interview exercises?
3. What did you learn from this module? What does it mean for you becoming a professional engineer?

You are not limited to just answering these questions in your reflection. Please include any other thoughts and feelings you think are important.

Submit your reflection (about two pages) as a PDF file on eLC.

Reflection prompt for Module 3

Think back through yesterday's module on **affective responding**:

1. How did these activities challenge and/or align with the ways that you think about yourself becoming an engineer?
2. Which parts of the exercises did you find particularly challenging/uncomfortable/useful/ [insert your other reactions here]…?

Submit your reflection (about two pages) as a PDF file on eLC.

Reflection prompt for Module 4

Read through the following statements and think of specific incidents they bring to mind. Write about them. You don't have to directly or specifically answer the statements.

- There was a moment during today's module when I started to realize that…
- During today's module, I struggled to get my head around…
- When my partner responded analytically to my story, I was surprised to feel that…

- When my partner responded empathetically to my story, I was surprised to feel that…
- As the engineer/stakeholder in the role play, I suddenly understood how…
- During the role play, I found it challenging to…

Submit your reflection (about two pages) as a PDF file on eLC.

APPENDIX B: IN-CLASS STRUCTURED NOTES FOR MODULE 1

Students are handed out a double-sided sheet of paper with the following questions on it (to be completed during class-time).

1. What is empathy?
2. Why is it important for engineering?
3. Notes from outrospection animation.
   [see video here: https://www.youtube.com/watch?v=BG46IwVfSu8]
4. Reflection questions for the first activity.
   a. How did you approach people /what did you do?
   b. What signals did you pick up from your counterpart?
   c. How did you feel throughout the exercise?
5. Reflection questions for the second activity.
   a. What was it like?
      i. To be the engineer? What did the residents say to you? What did you say/do in response?
      ii. To be the resident? What did you say to the engineer? What did they do? How did you feel?
6. What are the three most important take-aways from today's class for you?

APPENDIX C: EXAMPLE EXAM QUESTIONS

1. Describe the three elements of affective responding practiced in class. Write a brief exchange that illustrates these skills in a conversation between an engineer and a stakeholder.
2. In your own words, define, compare and contrast analytical and empathic forms of communication. Discuss the advantages and limitations of both approaches. Provide examples of when each form of communication is likely to be most effective.
3. Conversational turn taking is a key element of engineering communication. Define conversational turn taking, explain its role in teamwork, and provide examples for how you would promote conversational turn-taking in a group setting.

APPENDIX D: HOMEWORK ASSIGNMENT FOR THE UNIVERSITY OF ST THOMAS ADAPTATION - ENGINEERING ETHICS/EMPATHY/STAKEHOLDER ASSIGNMENT

Engineers are in the business of creating new products, technologies, systems and infrastructure to benefit society. In most projects, there are many stakeholders, or people whose lives will be impacted in a big or small way, by the outcome of a project. This potential impact on stakeholders is something that receives little attention in most undergraduate engineering courses whose primary role is to instruct you in fundamental engineering principles, concepts and problem-solving techniques. Thus, it is easy to lose sight of the importance of stakeholder feelings, concerns and engagement for an undergraduate as it does not receive the same emphasis as technical material. However, many practicing engineers are faced with the challenge of balancing technical needs against the desires of various stakeholders. These stakeholders can range from people within the company (say Marketing, boss, or project team member) to the end user of a product or even somebody who just happens to live near the end product (i.e. a pipeline running over your land).

Engineers, like most people, possess empathy, which is the ability to understand and share the feelings of others. While thinking analytically may be the more natural mode of operation for an engineer, it is also important that they switch into empathy mode at times. To avoid, or ignore, the feelings of potential stakeholders can result in a lot of wasted time and money. Think here of a project that is tabled due to public out-cry, or even lack of understanding of customer needs. Too often it is easy to forget that there are two sides (at least) to every story. Too often when facing a dissenting opinion or seemingly inappropriate action we fail to ask – "Why would that person think that, or do that?"

The aim of this assignment is to engage you in the act of thinking empathically in an engineering context and to identify if/how the NSPE code of ethics speaks to empathy expectations within engineers.

1. Read the NSPE Code of Ethics for Engineers in its entirety: https://www.nspe.org/resources/ethics/code-ethics
    - Does the NSPE code of ethics expressly state, or even imply anywhere, that empathy might be expected of engineers? Justify your answer while citing specific sections of the code as appropriate. (Let that liberal arts education shine!)

List of scenarios/interactions or potential interactions (***see below***) – based on real events/stories from working engineers – students choose a single scenario from the list and complete the assignment based on that scenario

- Background, stakeholder 1 (engineer), stakeholder 2 (could be a range of parties depending on scenario)

2. What additional stakeholders could there be with an interest in this scenario?
    - List as many as come to mind. What concerns could each of these have regarding this scenario and its potential resolution(s)?
    - Do these different groups all have equal priority or should some stakeholder's concerns merit greater consideration than others? Explain.
3. How do you think stakeholder 2 feels? If you feel comfortable sharing, briefly describe an experience from your life when you have felt similarly (a couple sentences are fine).
4. Write a short memo as stakeholder 2 to stakeholder 1 that takes into account their feelings while balancing any conflicting concerns. The goal of the memo is… (depends on scenario, roughly a paragraph)
5. How do you think stakeholder 1 feels upon receiving this memo? If you feel comfortable sharing, briefly describe an experience from your life when you have felt similarly (a couple sentences are fine).
6. Write a short response memo as stakeholder 1 to stakeholder 2 that takes into account their feelings while balancing any technical and ethical concerns. The goal of the memo is… (depends on scenario, roughly a paragraph)
7. Are there any aspects of the NSPE code of ethics that are relevant for the scenario you choose? Explain, while citing specific sections of the code as appropriate.

Assignment Reflection Questions

8. Why would an engineer want to approach a problem both analytically and empathically?
9. Which part of the assignment did you find most challenging? Why?
10. What part of the assignment did you enjoy or find rewarding?
11. What key insights do you take away from this assignment?

Civil Engineering Scenario

John (stakeholder 1) is a pavement engineer working for a major metropolitan city. As part of his job, John goes into all of the neighborhoods of the city to inspect the roadways and curbs to assess if they need repairs or replacement. Curbs can be a particularly tricky part of his job. When any part of a curb along a city block needs to be replaced, all of the homeowners on that side of the block receive an assessment that requires them to cover part of the cost of the curb replacement. The rest of the cost is covered by the city budget that effectively comes from taxes on all of the city residents. During an inspection in an economically depressed neighborhood, John notes that a few sections of curb along a block need to be replaced. Some of the curb that needs to be replaced looks to be in good condition but would fail to drain water towards the storm sewer properly. Some of the curb that needs to be replaced would drain properly but is in very poor condition with significant cracking. And there are large sections of curb that will drain properly and contain superficial cracking that should last for many more years which John decides to leave untouched.

Steve (stakeholder 2) is one of the residents along this street. He notices that some of his neighbors' curbs are being replaced while his, which looks to his eye to be in similar condition, is being left untouched. This raises confusion and concerns for Steve. He contacts the city to find out who made the decision about the curbs and is given John's contact information.

Mechanical Engineering Scenario

Liz (stakeholder 1) is a young manufacturing process engineer who is new to her job at a large engineering firm. Upon inspecting a pressure sensor manufacturing line, she notes some opportunities for improvement. The current line sends parts through in large batches to three consecutive stations – once all parts in the batch are processed at station 1, they move on to station 2, etc. If there is a quality issue in a component this system would install that fault into an entire batch of sensors before being detected at the last stage of testing. If a customer requires a change in sensors, the line would need to complete all the parts that have begun step 1 before changing over the fixtures to start work on the different sensor. In this manner, the current line presents avoidable issues that could be mitigated by having single parts pass through the system instead of batches.

John (stakeholder 2) is a technician who has worked on this pressure sensor manufacturing line for ~20 and basically followed the same process for all these years. John takes pride in helping produce parts that are instrumental to the operation of commercial and military aircraft. John has learned that there are changes planned in how the pressure sensors will be made. As far as he is concerned the system he has been using for years is perfectly fine as evidenced by the fact that the system has stayed the same so long, the continued high quality parts that are manufactured and seemingly happy customers.

Chemical Engineering Scenario

Delvin (stakeholder 1) is a research engineer for a large publicly-traded global petrochemical company. He and his team are developing a new type of plastic which has a broad range of applications including chemical piping. His area of expertise and research is on the stability and compatibility of chemicals with plastics. During his work, he has discovered that methyl ethyl ketone (MEK) rapidly reacts with a new plastic and could potentially degrade the mechanical integrity of pipe in contact with it. MEK is a significant health hazard to humans and is highly flammable.

Peter (stakeholder 2) is an engineering team leader and the supervisor of a variety of engineering groups involved with the testing, research, product development and market rollout of the new plastic. Peter, who is Delvin's boss, has a very optimistic and positive energy about him and is excited about finding new opportunities for his group's products. As part of his role, he leads teleconference calls that include many of the engineers from his groups, as well as his counterpart and engineers from another product development team in Europe. During one of these teleconferences, Peter announces with excitement that piping made from the new plastic has been installed in a test section of chemical plant containing high pressure MEK.

This is same plastic that Delvin is 90% certain is not compatible with MEK and could degrade over a short period of time. Delvin is participating in the teleconference and is immediately concerned about the potential failure of the pipe and the tremendously negative health impacts for the plant operators. Being caught off-guard, Delvin waits until the call ends to tell his boss about the potential problem in private.