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Exploring How Empathy Manifests with/for Teammates in a Junior-Level Biomedical Engineering Course

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Abstract

Teamwork projects are a common feature of undergraduate and graduate engineering programs and improved collaboration skills is an expectation of ABET accredited programs. Thus, it is important to understand factors that contribute to the development of more effective collaboration skills among engineering students. We posit that empathy is critical to working in teams, but limited research has explored how students empathize with team members in engineering education contexts. This study focuses on team experiences in a design course wherein students engaged in a group of three to four members. Specifically, we address the research question, "How did empathy manifest with and for teammates in a junior-level biomedical engineering design course?" We conducted semi-structured interviews with 19 students. The interview primarily focused on students' empathy for users and a concerted focus on teamwork experiences was a sub-component of the protocol. In analysis, we extracted passages in which students mentioned, talked about, or described their experiences as a team member, including ways in which they or their team members potentially empathized with one another. Using these passages, we performed a thematic analysis to identify how unique empathy types manifested therein. We found that it was often a challenge to extract peer-to-peer empathy types. Rather, students tended to talk about elements of the team that fostered or promoted an empathic teamwork environment, or what we refer to as collective empathy. Thus, in this study, we apply the concept of collective empathy to the interview data and, using these findings, we consider its applicability to studying empathy in engineering. We hope that these findings will position the engineering education research community to identify strategies to better promote students' abilities and tendencies to empathize with and for members. Moreover, we hope that this work will provide a foundation for future research focused on how empathy can promote more effective engineering design teams.

***Keywords*:** Empathy; Design Projects; Teamwork; Team Dynamics; Team Development

Introduction

Providing students with effective collaboration skills is a core and required feature of accredited undergraduate and graduate engineering programs. Thus, it is important to understand factors that contribute to more effective teaming experiences. One defining feature of effective intergroup relationships (and, thus, teams) is empathy [1-3] but relatively few studies in engineering education have focused on how students in engineering empathize with team members, how to support them in this endeavor, and how this, in turn, contributes to effective teams. As formal and informal teaming experiences pose many opportunities for conflict, particularly as teams seek to reconcile diverse views on appropriate decision-making or design strategies, this study aims to facilitate additional research in this domain. In this introduction, we indicate why a concerted focus on empathy in teams is worthwhile.

First, empathy can improve team member understanding. For example, Cuff et al. [4] suggested that empathy can help one understand others' needs and relate to them. These sentiments are a core consideration of Davis's [5] organizational model of empathy that connects antecedents, empathic processes, intrapersonal outcomes, and interpersonal outcomes. Empathic processes resemble the skills dimension of Walther et al.'s [6] model of empathy in engineering and manifest through perspective-taking, self/other awareness, and related skills. As this model emphasizes, however, one's orientation to others and one's behavioral dispositions also play a key role in determining whether one will empathize. Thus, as one example, numerous factors influence 'team member understanding.' Moreover, as Davis's model emphasizes, this type of intrapersonal understanding can promote interpersonal action or behavior.

Second, empathy can promote positive teaming environments. Such positive teaming environments may be evident through a lack of negative valences, such as limited frustration or stressful interpersonal conflicts, or by the presence of positive valences, such as psychological feelings of safety. The sequential processes by which empathy serves to promote such positive teaming environments may vary. For example, to use Davis's model as a heuristic, through perspective-taking one can generate intrapersonal understanding of one's team members and, in turn, respond with attentive sensitivity that demonstrates one hears, understands, and values peer perspectives. Thus, improved team member understanding can generate appropriate communication responses that show one 'hears you' and, in turn, can create stronger peer-to-peer relationships comprised of trust between the collective set of team members.

Third, empathy can reduce conflict in teams, particularly diverse teams. This sentiment was captured by Strobel et al. [7], wherein engineering faculty suggested that "a lack of empathy or care is detrimental to the proper functioning of inter-activities, such as working in design teams or solving multi-disciplinary problems." Diverse teams tend to experience conflict beyond homogenous teams, particularly as these teams introduce more opportunities for in/out group bias [8]. Indeed, such biases often serve as central to intergroup failures evident via a lack of interpersonal helping behavior [9]. Thus, Stahl et al. [10] performed a meta-analysis of culturally diverse teams and found that most studies have identified cultural diversity within groups to lead to "process losses through task conflict and decreased social integration." Empathy can help reduce such conflict by enabling others to value and engage with others' perspectives. For example, Pettigrew and Tropp [1] performed a meta-analysis of over 500 studies and found that empathy was one of three strong mediators for reducing prejudice in intergroup contact experiences. Thus, conflict resolution training tends to focus on fostering empathy within teams in order to help reduce such conflict [e.g., 11, 12].

Fourth, empathy can bolster team creativity. In this vein, DiStefano and Maznevski [13] postulated that the "key to unlock creative synergy was in the team's interactions process, in how they understood, incorporated, and leveraged their differences" (p. 48). In this same sentiment, Stahl et al. [10] found that culturally diverse teams that effectively alleviated conflict, in turn, often exhibited "process gains through increased creativity and satisfaction" [10]. These findings were supported by Alzayed et al. [14] who found that teams comprised of more empathic individuals led to improved idea generation.

Study Overview

As empathy plays a critical role in teaming experiences, it is important to understand how students empathize with/for teammates, including the instructional design choices that instructors may employ to facilitate students' tendencies to empathize with/for teammates and the outcomes that result therefrom. This study focuses on teaming experiences in a junior-level biomedical engineering design course wherein students engaged in a group of three to four members in an ill-structured design project. We address one research question in this study: (1) "In what ways does empathy manifest with/for team members in a junior-level biomedical engineering design course based on post-course interview reflections?" We hope that this investigation will facilitate future work that can help instructors promote empathy in teams, help researchers identify how to "see" empathy's manifestation in teaming contexts through qualitative data, and to help the engineering education community better understand the design outcomes that empathic teams tend to produce.

Literature Review

In this literature review section, we address the question, "What is empathy?" We approach this question broadly and thus do not constrain ourselves to how scholars have studied empathy in teaming experiences in engineering or engineering design contexts.

Empathy is a complex phenomenon with various extant frameworks used to understand and conceptualize it. Batson [15] identified eight discrete but related empathy types that are oft-studied in social neuroscience literature and that tend to vary based on two different foci: (1) "processes whereby one can come to know the internal state of another" and (2) what causes them to "be motivated with sensitive care" (p. 11). These eight empathy types include sentiments such as "imagining how another is thinking and feeling" and "feeling distress at witnessing another person's suffering" (p. 7). Building on the framing undergirding the Interpersonal Reactivity Index [16], Hess & Fila [17] mapped four of Batson's eight empathy types along two continua: self/other-orientation and affective experiences or cognitive process (see Figure 1).

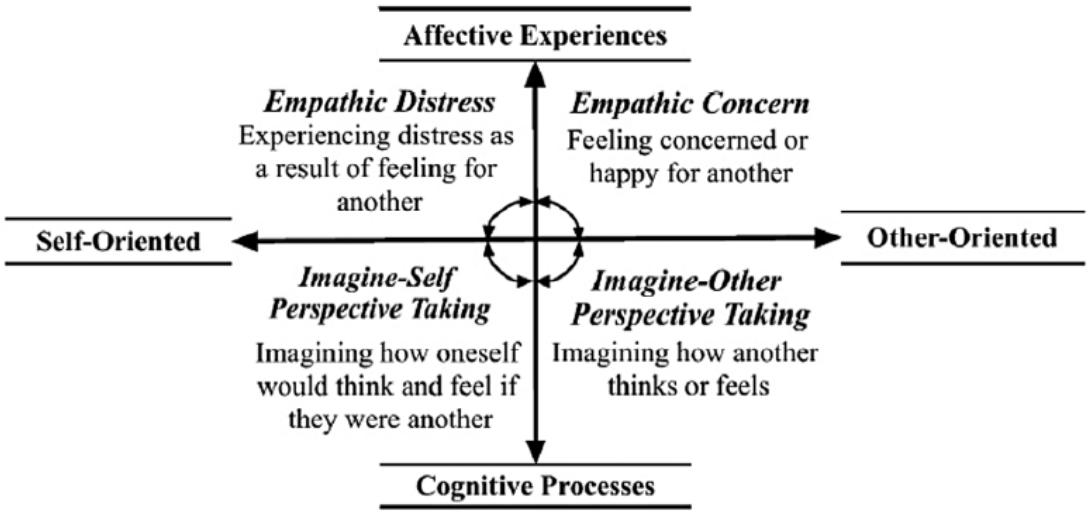

Figure 1. Empathy Types (taken from Hess & Fila [17])

While discrete, affective and cognitive empathy types tend to inform one another. Walther et al. [6] described moving between "empathic and cognitive mechanisms" as "mode switching," a sentiment that also may capture the specific notion of moving between cognitive and affective empathy types. Similarly, Hoffman [18] described the process of moving between self/other orientation as pluralism. In the context of design, Smeenk et al. [19] describe the overall process of moving between factors that affect empathy in design as "mixing perspectives." Thus, mode switching, pluralism, and mixing perspectives call attention to how individual empathy types may inform other empathy types.

Affective and cognitive empathy types can work in conjunction to promote behavior. Many measures of empathy include and differentiate between affective and cognitive empathy types, but also behavioral facets of empathy, wherein behavioral empathy as oft-measured by psychometric instruments tends to differentiate between "behavioral mirroring" or "empathic communication" [20]. There is a lack of consensus in extant literature both inside and outside of engineering regarding whether 'behavior' is an outcome of affective or cognitive empathy types or whether "empathy" requires behavior. For example, Batson's [15] eight empathy types seem to suggest that empathy can *motivate* caring or helping behavior.

There is a concerted and growing body of knowledge on empathic behaviors, particularly *empathic communication* in engineering education. This growing body of work supports the notion that focusing on the interrelationship between empathy types is critical for understanding empathic communication behaviors. For example, Walther et al. [22] developed four empathic communication modules that helped students harness or reflect on four empathic skills: (1) affective sharing, (2) self and other awareness, (3) emotion regulation, and (4) mode switching. Walther et al. [6] later developed a three-part model of empathy in engineering comprised of skills, orientations, and ways of being to emphasize the interconnected nature of empathy types and these ways of viewing empathy. For example, they explain that the skill component "is comprised of five distinct, socio-cognitive processes [the four module topics plus perspective taking] that interact with each other to form the foundation for empathic communication, relationship building, and decision making" (p. 133). Moreover, Sochacka et al. [23] identified the challenge of empathy instruction by unpacking five themes which represent variation in ways that students engaged with the empathic communication modules. This variation was largely based on how students viewed the role of empathy in engineering with students (1) not engaging, (2) equating empathy with communication, (3) learning to listen, (4) viewing empathic communication as a practice, and (5) embracing empathy as a way of being.

Collective empathy offers yet another lens for considering the phenomenon of empathy. Collective empathy emphasizes the interrelationships between individuals, such as the members of a team, including the extent to which members exhibit emotional rapport and appreciate others' thoughts and perspectives. Specifically, Akgün [24] defined collective empathy as "an appreciation and understanding of what team members are experiencing emotionally, as well as an emotional reaction to other team members' feelings." Thus, collective empathy involves empathy as a shared experience between two or more individuals. ***We think that collective empathy may be particularly useful as we consider empathy in teaming experiences.***

Methods

Data Collection

Participant Recruitment and Overview

Participants in the interview activity were 20 of 91 students enrolled in a junior-level undergraduate biomedical engineering design course during the Spring 2020. Due to poor internet connectivity and audio issues, we did not analyze one interview, thus reducing our interview sample to 19. The course focused on the early stages of the design process and has students worked in teams of four to identify user needs and ideate on potential design foci that they might carry forth to senior design the next academic year. In addition to design skills, other topics of the course included business considerations, professional communication skills, and ethics. We did not collect demographic data in this study but postulate that university demographic data roughly align with our participant sample. The university includes over 40,000 students, 24% of which are minority domestic students and 43% of which are female.

Student participation in interviews was voluntary but instructors incentivized participation through extra credit. Students were able to receive extra credit either by participating in the interviews (which used as research data) or a reflection assignment (which we did not use as research data). To facilitate participant recruitment, the course instructor introduced information about the opportunity in-class and then forwarded an email from the research team that provided additional details. In turn, prospective interviewees reached out to the research team wherein the students provided a pseudonym that we utilized in interviews and to report results in this study.

Interview Procedures

One author conducted all interviews virtually via Zoom due to COVID-19. We encouraged interviewees to turn on their cameras during the interview to facilitate improved communication between the interviewer and interviewee. We recorded interviews using MP3 Skype recording software, but to alleviate the risk of losing recorded data, we also used a physical recorder as a backup. Throughout interviews, we used participants' self-selected pseudonym. We initially transcribed interviews via a third-party, Trint, and then we checked interviews for anonymity and accuracy. The interviews were between 43 and 98 minutes in duration.

Interview Protocol

The interview structure included four primary sections: (1) Background, (2) Design Experience, (3) Conceptions of Empathy, and (4) Closure. The majority of the interview was devoted to "Design Experience", which prompted participants to reflect on their junior design experience, including their team interactions, needs finding, concept generation, project evaluation, user-centered considerations, cognitive empathy, and affective empathy. While team interactions were a sub-component of the protocol, in this study, we extracted passages in which students mentioned or described their experiences as a team member based. Thus, students may have described teaming experiences in other aspects of the protocol. As just one example, the affective

empathy section opened with the question, “Who or what were you concerned for during your design project?” A subset of students followed this prompt by describing teaming experiences.

Data Analysis

We employed an inductive content analysis that included (1) Familiarizing ourselves with the data; (2) Reducing data to teaming experience passages; and (3) Deductive and inductive coding. The remainder of this methods section includes subsections devoted to these steps. While we present these steps as linear, we often moved between steps, revisiting earlier steps later in the process and vice versa.

Step 1: Familiarizing Ourselves with the Data

We began analysis with the intent to address the question, “How did empathy manifest with/for teammates in a junior-level biomedical engineering design course?” Moreover, at this stage, we intended to analyze whole transcripts. However, the interview protocol and follow-up questions generally prompted considerations of empathy with/for users. Thus, we identified an opportunity to reduce data to specific teaming experiences.

Step 2: Reducing Data to Teaming Experience Passages

We extracted passages that contained one or multiple sentences referring to a teaming experience and which potentially included evidence of empathy with/for team members during the junior-level biomedical engineering design project. As it was often a challenge to ascertain if interviewees exhibited empathy with/for teammates, we broadened this consideration to *potentially* utilizing empathy. This potentiality was based on some discussion of emotional or cognitive experiences involved in student interactions with other team members. One author initially extracted all potential passages guided by these criteria, followed by a second reviewer. When the second coder was uncertain as to whether the passage met these criteria, they in turn reviewed the whole transcript and sought to identify if the addition of surrounding text would lead to agreement. In most instances, the second coder was able to combine this text with adjacent interview text. These blocks of text, or “passages,” became the focus of coding.

Step 3: Deductive and Inductive Coding

Third, we engaged in deductive and inductive coding. While coding was primarily deductive, we were cognizant of Batson’s [15] eight empathy types. In particular, we began by focusing on coding the four empathy types emphasized by Hess and Fila [17]: (1) imagine-self perspective-taking, (2) imagine-other perspective-taking, (3) empathic concern, and (4) empathic distress. While these were the primary deductive codes we brought to analysis, we sought to identify at least one empathy type in each passage. However, this key inclusion criteria (i.e., the explicit manifestation of empathy in passages) challenged our initial conceptualization of empathy. This also led to a broadened conceptualization of what constitutes empathy with/for team members. Specifically, given our sense that teams were “empathic” in lieu of students’ explicit recognition of the use of these four empathy types in many passages, we identified the potential to integrate Akgün’s [24] conception of ‘collective empathy.’ Thus, like Akgün et al., we brought a

deductive coding framework seeking to identify 'cognitive,' 'affective,' and 'behavioral' elements of *collective empathy* [24].

Step 4: Narrating Codes and Checking Passages

Finally, once we established a final set of codes, we developed a shared agreement and narration of these codes. In turn, we revisited all coded passages to identify their alignment with our final established coding framework.

Results

In this study, we addressed the research question, "How does empathy manifest with/for teammates?" We differentiated between two broad categories of codes (1) peer-to-peer empathy and (2) collective empathy. This section includes two sub-sections devoted to these categories.

Peer-to-Peer Empathy

"Peer to Peer" Empathy types manifested as empathy between two individuals: the self and one other. Thus, while teams included multiple individuals, these interview passages tended to only make evident considerations for one other individual or team member (see Figure 2).

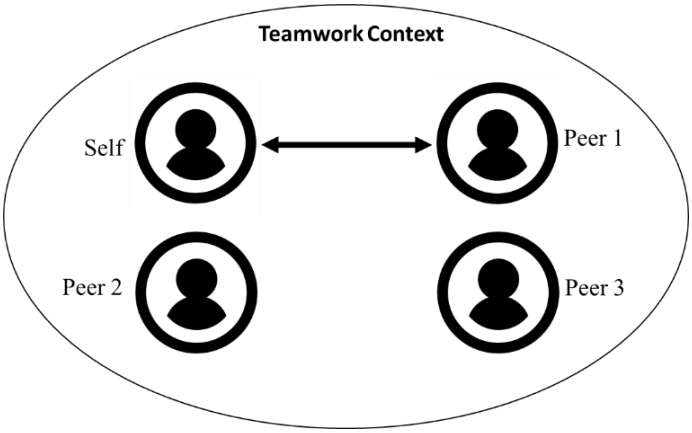

Figure 2. Emphasis of Peer-to-Peer Empathy Codes

Empathy codes manifested as cognitive processes (e.g., *perspective-taking*), affective experiences and outcomes (e.g., *empathic distress*, *empathic concern*), or cognitive intrapersonal outcomes (e.g., *understanding peer perspectives*). We initially relied on an extant four-part framing (see Figure 1, taken from Hess and Fila [17]) and to an extent this four-part framing was useful. However, we found that participants' responses seldom distinguished self- and other-oriented perspective-taking. Thus, we combined "imagine-self" and "imagine-other" forms of perspective-taking into a single 'perspective-taking' code. Moreover, these passages found team members sharing their understanding of a peer's perspective regardless of the underlying perspective orientation. Thus, we added one code to capture this specific intrapersonal outcome (i.e., *understanding peer perspectives*). Table 1 provides an overview, description, and associated quote for these individual empathy codes.

Table 1. Peer-to-Peer (Individual-to-Individual) Empathy Codes

Empathy Code	Description	Example Quote
Empathic Concern	Feelings of concern for a team member.	I don't want them to feel like that is throwing out an idea into a void. - Linda
Empathic Distress	Feelings of distress that occur or result from team member interactions.	When you feel the pressure, you're either motivated by it or you're completely crippled. Pause. Taken aback by it. Frozen. Almost. - Linda
Perspective-Taking	The cognitive process of imagining team members' perspectives.	Those are those design criteria. So, if my teammate talked about the design criteria that she thought were very important and then I looked at the existing solutions, I would see that, okay, those ideas that they did think about them and those solutions. But they didn't think about something else that my teammates did not mentioned or did not think about. - Feedsys
Understanding Peer Perspective	An understanding of a specific peer's perspectives.	I could have been maybe more understanding of Sterling and like why he acts the way he does or why he does anything that he does. But I think I think I did a, I think I did a pretty decent job. - Arya

While *empathic concern*, *empathic distress*, and *perspective-taking* were present, we observed few instances of these types in the dataset. We posit that the limited manifestation of these empathy types with/for teammates may be partially based on our data collection strategy, as empathy with/for teammates was a limited interview component (the interviews focused on empathy with/for users). As we describe next, collective empathy was more prominent in the dataset than these peer-to-peer empathy codes.

Collective Empathy

While passages sometimes included evidence of peer-to-peer empathy, this was not always the case. However, all passages included some description of either the *process* of developing shared perspectives/feelings or *outcomes* representing shared perspectives or feelings among all peers.

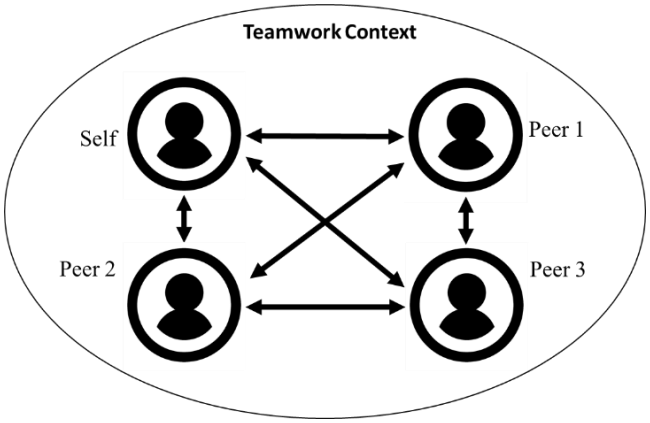

Figure 3. Focus of Collective Empathy Codes

Figure 3 seeks depict to “collective empathy,” or the confluence of peer-to-peer empathy diffused across all members of the team. The repeated use of collective pronouns (e.g., “we”, “us”) combined with cognitive, affective, or behavioral language suggested processes contributing to the development of these shared states or understandings.

Affective Collective Empathy

Affective collective empathy manifested as the shared feelings or motivations amongst team members. For context, example survey items from Akgün [24] associated with collective affective empathy include, “Our team members tend to get emotionally involved with others’ feelings within our team,” and “The attitudes of team members are affected by the feelings of others within our team.” We generated two sub-codes associated with affective collective empathy that guided our understanding of this phenomenon and that aligned with these survey items: *team comfort* and *team contagion*.

Team Comfort (Camaraderie, Safety, or other Shared Positive Feelings). This code speaks to the diffusion of positive emotions throughout the team, including shared feelings of comfort, camaraderie, safety, or other positive feelings. For example, Linda stated:

> All of these kind of positive aspects of these people, well work ethic of these people, came into play a lot. And then just because they were all pretty kind and respective towards each other and their thoughts and ideas, that made it all really mesh together and made them be able to share their opinions really openly. Yeah. And it made us just get stuff done quicker, too. Because normally if we did have like have a disagreement, we just said, oh, hey, this looks different from each other. Let's fix it now. - *Linda*

As a second example, Green talks about the ‘fun’ team environment and how this fostered friendship and streamlined communication.

> We always have fun through the design process. We became good friends. So that made it easier to just relax. And I've been a part of teams that we don't really interact with each other too often. We don't talk about anything other than the work at hand. And that made the design that made working with that team less, less fun and communication was down in that team. So here we could communicate a lot and it'd would be, it would be fine. No one would bash you or anything like that. So basically communicating our different ideas or different issues was easy. - *Green*

Team Contagion (Emotions, Empathy, or Motivation). This code represented the diffusion of and internalization of shared emotions throughout the team. Thus, the code often manifested as a ‘collective’ variation of emotion contagion [25]. In other passages, this code manifested as what we describe as *empathic contagion* whereby one team member empathizes with a user which, in turn, fuels empathy for that user among other team members. Generally, this ‘empathic contagion’ translated directly or indirectly into a shared motivation among team members in terms of shared empathy (e.g., concern) for a specific user group. This sentiment is expressed in the following interchange between Emick and the interviewer (we provide ellipses to shorten the overall text and emphasize the connection between users the team’s shared motivation):

> **Interviewer:** Can you … describe a specific instance where you felt concern for users?
>
> **Emick:** I think our biggest concern for users that our team came across ways, you know, how they can afford this health care is expensive no matter which way you slice it. […]
>
> **Interviewer** Could you tell me what motivated this concern or these concerns?
>
> **Emick**: So, I think it really made us a concern was one of our teammates actually has a sibling that goes with a peritoneal dialysis. […]
>
> **Interviewer**: Were there any factors in your course that influence how you used empathy?
>
> **Emick**: I'd say the fact that one of our team members has a has a sibling that's on PD was a big factor ***and it was definitely a definite drove us to… you want to make a viable solution because now it was a personal matter***.

Cognitive Collective Empathy

Cognitive collective empathy represents team members seeking to engage with and understand perspectives amongst all members on the team during the design project, integrating these into the design solution, or developing a shared understanding among team members (i.e., a collective team perspective). For context, survey items from Akgün [24] associated with collective empathy include, "On our team, we make an effort to understand one another's attitudes and views," and "Our team members understand what others within our team are thinking." [24] We developed a single code, *considering or developing a team* perspective, to capture these sentiments.

Considering or Developing a Team Perspective. This code speaks of the general process of considering all team members' perspectives or striving to create a shared team perspective. For example, Austin discussed how the team remained cognizant of peers' perspectives:

> We thought of them [the users] and also, we thought of ourselves as well. Do you do we think we're able to do this project? Is this something that we could actually do? We have the expertise can we source the expertise to do this and that that remains to be seen. But we didn't want to pick some we don't want to try to do something that would be totally out of the realm of our capabilities. - *Austin*

In this longer example, Boiler discussed how the team actively engaged with peer perspectives and how this helped contribute to an overall improved design. This excerpt was also notable as Boiler began by briefly discussing his perception of the value of multiple perspectives. In turn, he referred to *perspective-taking* and then quickly moved onto overt empathic communication acts, with the remainder of the discourse focused on communication activities the team utilized to improve and generate a shared understanding:

> **Interviewer:** How did your team member interactions inform your design process?
>
> **Boiler**: I think part of it was just that we all have we all see things differently. So, things that I might not think of someone else might think of something that someone else might

not think of. I do think of. So, I think having more people on a team and interacting with them and talking things through within I think makes it a better solution overall. Just because we are going to miss something just because one person like I didn't think of that. I think with more people, that just kind of makes it easier not to miss things.

Interviewer: And how did you deal with that? I mean, I can see the positive aspect that you mentioned. How did you deal? Everyone is looking and proposing different things.

Boiler: We just sat down and discussed it and kind of like tried to see things from different people's point of view. So, like when one person mentioned something and like you hadn't thought of that before, then just sitting there and thinking about that for a little bit and then like continuing the discussion. And if you had questions asking those questions and trying to understand, like if you did miss some things, then try and understand that so you aren't going to miss that same thing again when we're on the next step of the project. – *Boiler*

Behavioral Collective Empathy

Behavioral collective empathy portrays a general openness, willingness, and intentionality to support peers or to communicate ideas empathically. For context, example survey items associated with this construct from Akgün [24] included, "In a coordinated manner, our team members demonstrate verbal and non-verbal communication reactions in response to the feelings of others within our team," and "Our team members react in response to the feelings of others within our team." We divide this code into three sub-codes, with two codes emphasizing *cognitive* and *affective* communication acts and a third emphasizing general *helping behaviors*.

Cognitive-oriented communication. Teams often exhibited communication patterns that ensured all team members developed a shared understanding via purposeful strategies to express, listen to, and respond to the perspectives of all individuals on the team. This type of communication often manifested as a normalized (or formalized) modality for communicating in the team to ensure all team members could share their perspectives. For example, Jack stated:

If one of us had an idea about the design, we would ask each other. I mean, we talked about it and then basically that would determine if we moved forward with that or not. So, it wasn't just like one person had an idea and then they just went with it. It was one person's idea. They presented the idea. We all talked about it. And then if we all decided it was a good idea, then we went forward with it. […] So, we would think about, "Okay, maybe not like that, but maybe we could do something branching off of that." So maybe like this quote-unquote stupid idea would branch off to what we actually did do. So, we were never like, we were never, we were always positive about what each other said. We were always, you know, positive, constructive feedback. So that's that's how we went forward. – *Jack*

Affective-oriented communication manifested as respectful, kind, or encouraging feedback. Thus, this code often exhibited overlap with the *comfort* affective collective empathy code. For example, Linda compared and contrasted her current teaming experience with a prior team:

> So, you can feel out in effectiveness almost once you've had a group that's been pretty bad. So, this group, very positive atmosphere, talking to them, very relaxed. When we got done with other calls, we would get life updates from each other. So, stuff like that was really important. I think just to get a positive feeling from a group because that feeds into and I'm willing to share an opinion. Am I willing to share an idea? Is it going to be taken well? Is it going to have constructive criticism that's positive or negative but kind? you know. So, I think just being in a group that's kind worked a lot for me in general. - *Linda*

Helping/supporting peers. This code described instances of team members supporting each other. While distinct from the communication codes above, helping or supporting peers often manifested through some form of communication and often seemed to result from or in relation to other empathy codes. For example, Austin discussed team comfort and how the willingness of team members to support each other facilitated team comfort:

> **Interviewer**: In what ways do you think your team interactions helped contribute to a positive overall design process?
>
> **Austin**: For the positive overall design experiment, I think that helping each other out was a big part of making it positive for everyone involved. So, you know, it could be tough on someone individually and then starting the team as a whole if someone wasn't able to carry their weight. So, I think that making sure everyone was able to complete their part time meeting consistently. Everyone met consistently without any problems. So, everyone, you know, thing, especially now, was a good part of making it more positive overall. I think just like individual accountability, combined with a willingness to help other people, made it positive. I mean, it could have been not positive at any one individual member not being responsible and responsive, not being willing to help people out. But everyone seemed to be willing to do that. So that's what made it good, I think.

<u>Overlap between Empathy Codes</u>

While the passages sometimes contained a single empathy code (i.e., peer-to-peer *or* collective), most passages included multiple empathy codes. As one example, a single passage by Linda revealed how one team member's familiarity with users prompted her own internalized motivation - "those kids really motivated me" - and how this diffused across the team – "let's get on board with this because someone finds passion in this" – which helped Linda develop a greater understanding of peers – "So it seemed like a real passion of hers." As Linda stated:

> I think just recently I've gotten motivation from other aspects. I had a really good group. Those kids really motivated me. Really the most because they were overachievers from the very beginning. So, I felt like, OK, if they're overachieving, I got to also pull my weight to a higher extent. […] One of our team members, she ended up being really passionate about this idea, helping wheelchair athletes. She's an athlete herself. She's been going far and beyond in extracurricular activities to just raise money, raise awareness for wheelchair athletes and stuff. So, it seemed like a real passion of hers. And because of that, it seemed like all of us really respected that. And we were like, "Okay, Let's get on board with this because, you know, someone finds passion in this. We're bound to have some good outcomes come of it." - *Linda*

Table 2. Collective Empathy Coding Overview
Note: Passages that include more collective empathy codes are at the top, and we omitted passages with only peer-to-peer codes.

Passage	Team Comfort	Team Contagion	Considering or Developing a Team Perspective	Cognitive-Oriented Communication	Affective-Oriented Communication	Helping or Supporting Peers
Mandy-1			x	x		x
Emick-1/2			x	x	x	
Feedsy-1		x	x	x		
Linda-2	x			x	x	
Austin-1	x					x
Boiler-1			x	x		
Chef-1	x		x			
Chef-2	x			x		
Edith-1					x	x
Edith-2	x				x	
Green-1	x		x			
Green-2	x				x	
Jack-1			x	x		
Jo-1	x					x
Linda-5	x	x				
Lyli-1			x	x		
Amy-1				x		
Amy-2		x				
Amy-3	x					
Austin-2			x			
Austin-3		x				
Emick-3		x				
Emick-5				x		
Jack-2	x					
June-1				x		

Table 2 provides an overview of coded passages. As Table 2 shows, we coded at least one collective empathy code in 27 of the 29 passages, and individual passages contained between one and three collective empathy codes. Six passages included both *considering or developing a team perspective* and *cognitive-oriented communication*. The second most overlap was between, *team comfort* and *affective-oriented communication*, which overlapped in three passages. There were many other instances where codes overlapped in at least two passages. These findings suggest that codes interconnect, but they also indicate that codes may manifest in isolation.

Discussion

This discussion opens with considerations for understanding/researching empathy in teaming contexts. Next, we consider how these findings might align with or differ from other oft-studied team constructs. Finally, we close by offering future directions for research.

Understanding how empathy manifests in teaming contexts

In this study, we began by employing a model comprised of four empathy types: empathic distress, empathic concern, self-oriented perspective-taking, and imagine-other perspective-taking [17]. We found that students sometimes spoke of their concerted use or experience with these empathy types, but that seldom were such peer-to-peer considerations explicit. Rather, students often spoke of the team holistically, describing *collective* considerations of emotions or perspectives between all (or multiple) individuals on the team. Thus, we employed the concept of *collective empathy* to capture these collective sentiments. Moreover, like many others empathy researchers [20], including Akgün et al. [24], we differentiated between affective, cognitive, and behavioral facets of empathy as we applied this collective empathy concept. Here, we briefly describe sub-codes we generated aligned with Akgün's tripartite model of collective empathy, the relationship between constructs, and ongoing challenges that we continue to grapple with regarding what qualifies as "empathy" versus other team constructs.

Affective collective empathy

Like one-to-one or peer-to-peer affective empathy, affective collective empathy emphasizes affective and emotive considerations. However, rather than focusing on shared affects between two individuals, the focus of this construct is the collective team, thus representing shared affects diffused throughout a team of more than two individuals. We generated two sub-codes associated with this construct: *team comfort* and *team contagion*.

First, *team comfort* serves as a corollary to empathic distress but emphasizes positive feelings. This is not to suggest that stress is a 'bad' emotional state but rather that when one experiences stress, one may feel uncomfortable and, therefore, seek to alleviate their distress [18]. On the other hand, individuals often aspire to promulgate positive feelings. In this sense, many passages found individuals explicitly using the word "positive" or related positive affective elements such as "camaraderie" or "enjoy[ing] each other's company." Our inclusion criteria of empathy passages – i.e., *presence of empathy* – likely played a significant (albeit, unintentional) role in surfacing these positive affective empathy types. Thus, while empathy research has "focused

overwhelmingly on empathy for the negative emotions of others" [26], this study supports the need for future work that concertedly focuses on *positive empathy* in engineering teams.

Second, while empathic distress emphasizes how one feels, this collective construct references how the overall team (i.e., "we") feels. In other words, these passages emphasized that all individuals in the team shared positive feelings. While passages seldom emphasized one-to-one considerations, we conjecture that peer-to-peer positive rapport served as the undergirding context for the collective positive rapport. For example, *team contagion* manifested as a shared form of emotion contagion; it is likely that interpersonal emotions first diffused amongst a subset of peers and, eventually, the collective. Finally, while *team comfort* emphasizes the positive affective outcomes (e.g., comfort, safety) and *team contagion* emphasizes the diffusion process, there is likely an interactive effect between these collective empathy constructs.

Cognitive collective empathy

This construct emphasizes the development or consideration of a shared team perspective. Thus, as the name indicates, passages found members of the team cognitively engaging with others' perspectives. Through this form of cognitive engagement, the team was able to develop a shared understanding of the project and a consensus perspective that encapsulated all team member perspectives. While peer-to-peer *perspective-taking* could precede cognitive collective empathy and thus help inform the shared perspective, rarely did students vocalize their overt consideration of individual peers' perspectives. However, once peers vocalized their perspectives, team members showed a willingness and, often, a commitment to engage with those verbalized perspectives. Thus, we saw significant overlap with this code and the behavioral collective empathy codes.

Behavioral collective empathy

Clark et al. [20] suggested that behavioral empathy manifests in one of two modalities: (1) "behavioral mirroring" or (2) "empathic communication." Our codes in this study primarily aligned with the latter. Moreover, Akgün et al. [24] defined behavioral empathy as "engagement in helping behavior, usually expressed as the *communicative reaction* of people to others' feelings." We generated three sub-codes in this study, and these emphasize the *helping* and *communicative* facets, wherein we divided communication into *affective-oriented communication* and *cognitive-oriented* communication. Each of these communication modes found participant discourse facilitating, supporting, or in response to other empathy codes. Thus, we suggest that other researchers think about empathic communication (and potentially other classes of empathic behaviors) in terms of their emphasis on engaging the cognitive (i.e., engaging perspectives) versus the affective (i.e., engaging feelings).

These findings also indicates that there is an opportunity and need to solidify the understanding of what constitutes *empathic communication* in engineering teams. Based on our analysis, we propose that empathic communication be operationalized as either *promoting* or *resulting* from individual or collective empathy types. Thus, empathic communication acts can support distinct aspects of empathy (e.g., the cognitive versus the affective) or result therefrom.

Relationship between collective empathy codes

We often saw connections between codes, particularly the collective empathy codes. For example, *considering or developing a team perspective* often overlapped with the *cognitive-oriented communication* code. This overlap indicates how critical communication is to develop a shared perspective. While this was the most prominent overlap, several other relationships between code were apparent. For example, *team comfort* overlapped with *considering or developing a team perspective* in multiple instances, thus suggesting that teams wherein individuals have a shared positive emotional state can also promote opportunities for developing a shared perspective. However, we are cognizant that such situations might also generate groupthink and, thus, may not always be ideal. Thus, there is a need for future research on how these distinct empathy codes support each other. We posit triangulating considerations represented by these empathy codes and extant teaming constructs that are like these constructs would be perhaps the most immediately viable way to consider such interconnections.

Ongoing challenges with the collective empathy concept

We found that we could extend how we often consider empathy at the one-to-one level to the collective; in other words, we found the concept of collective empathy to capture more traditionally defined empathy-like phenomena. However, we struggled with applying the concept to the dataset in three ways. Our ongoing challenges include: (1) uncertainty whether a team can have 'partial' collective empathy, such as when three of four teammates appear in unison; (2) uncertainty about who is part of the "collective" – is it just the team members or might it include others beyond the 'traditional' team context (e.g., users, instructors); and (3) the similarities and distinctions between collective empathy codes and other extant team constructs. We briefly consider this latter point in the following section.

Collective Empathy versus other Team Constructs

Here we briefly address the question, "How do these 'collective empathy' codes align with or differ from other constructs that have been studied in engineering teams?" While perhaps obvious, engineering teams are comprised of human beings and virtually all teams require that individuals interact with each other in some modality. We hypothesize that high-quality teamwork interactions will produce high-quality teamwork outcomes, and that empathy plays a critical role in promoting quality intergroup interactions [1].

Prior researchers have focused on *team effectiveness* [27], focusing on the inputs, processes, mediators, and outcomes relevant to effective teams, but rarely have these studies explicitly focused on *empathy* throughout these processes. Our long-term goal is to develop such a model, but as a first step we sought to simply identify how empathy manifested with/for empathy teammates. While the collective empathy codes we applied in this study were pervasive, these codes are like many extant teamwork constructs. In this section, we briefly consider similarities and differences between these collective empathy codes (affective, cognitive, and behavioral) and select team constructs.

Affective Collective Empathy or Team Satisfaction?

Affective collective empathy codes spoke to the diffusion of positive emotions throughout the team (*team contagion*) and the resultant outcomes (*team comfort*). These sentiments align with considerations pertaining to *team satisfaction*. For example, Van der Vegt et al. [28] argued, "Little is known about how group members *affectively respond* to different types of interdependence, or the combinations of interdependencies that make members feel satisfied with their jobs and the groups in which they work" (emphasis added, p. 51). To this end, Van der Vegt et al. studied the relationship between *group-level task interdependence* and *team satisfaction*. The team satisfaction items employed by Van der Vegt seem to focus on *individual affective outcomes*. Conversely affectively collective empathy emphasizes the *process of diffusing shared emotions* and their *collective impact*. Other authors have considered what factors influence team satisfaction, such as team characteristics, clear project goals, clarity about evaluation and rewards, effective leadership, management support, and manageable levels of conflict and stress [29] (p. 33). Like *team contagion*, these variables act as inputs or moderating variables informing team comfort or team satisfaction, respectively.

Cognitive Collective Empathy or Shared Mental Models?

We identified *cognitive collective empathy* via the single process code, *considering or developing a team perspective*. While this code speaks to the objective of creating a shared team perspective, no students gave voice to this meta/collective team perspective. Nonetheless, we think this outcome is very similar to concept of *shared mental models*, a common concept employed in team effectiveness literature [27]. As Borrego et al. [27] state:

> The concept of shared mental models is useful in understanding how teams approach complex, ill-defined projects, and may be particularly useful for understanding interdisciplinary team effectiveness. Shared mental models or team mental models are knowledge structures that enable a team to form accurate explanations and expectations of the task, to coordinate their actions, and to adapt their behavior to demands of the task and other team members [27] (p. 495).

Thus, *shared mental models* or *team mental models* call attention to shared or emerging knowledge structures that enable teams to collaborate. Often, team mental models "refer to knowledge structures or information held in common" [30] (p. 83). There is sometimes a distinction made between a shared mental model about *the task* versus a shared mental model about *team members* or the *team as a whole* [30].

Thus, like the collective empathy codes, shared mental models emphasize the interrelationships between individuals and the collective. We postulate that instances where students might consider the team perspective, thus asking "What do *we* know?" distinguishes between these codes. Thus, shared mental models draw attention to *the common/shared knowledge across a team*, whereas the process of collective cognitive empathy draws attention to individuals *considering or purposefully developing a shared/collective perspective*. Unsurprisingly, we saw significant overlap between such considerations and overt communication acts.

Empathy or Communication?

Throughout this study, we often questioned if vocalized *cognitive* engagement with others' perspectives was a form of *communication* or, more specifically *empathic communication*. With communication acts themselves, we also often asked, "Is this informing peer-to-peer or collective empathy or the outcome of peer-to-peer or collective empathy?" Thus, like Clark et al [20], we agree that "additional conceptual and empirical work is needed to identify the breadth of behaviors involved in empathic communication and how these behaviors may differ for demonstrations of cognitive versus affective empathy" (p. 169). Thus, we call for future considerations of what distinguishes *empathic* communication from other modalities of communication in engineering teams.

Limitations and Future work

Our long-term objective is to provide useful insights and guides for fostering empathy in teamwork contexts to help improve engineering teaming experiences. The rapid sequence between empathy types was one of the initial challenges of this coding. Considering this challenge, we propose several next research steps towards this end that will build directly on this study's findings. First, we will code for teamwork processes and outcomes, thus identifying the potential interrelationships between empathy and team outcomes. Second, we will compare coding between team members on multiple teams, thus identifying potential (mis)alignments between team member perspectives and experiences with empathy. Third, we have rich video data following one engineering design team throughout the course of a semester. We will extend these interview analyses to focus on this very rich dataset via a narrative analytic lens. Finally, we will also plan to iterate on our interview protocol to bring in a more concerted focus on how empathy manifests with/for team members, including a concerted focus on our still emerging understanding of collective empathy.

Finally, we want to explicitly thank, recognize, and respond to a suggestion from an ASEE reviewer who noted:

> I am somewhat concerned that student experiences of empathy are introduced and studied entirely apart from structural conditions that have long been understood to shape the affective features of engineering teaching and learning. Without some reference to the discouraging conditions faced by minoritized students in Engineering programs, routine ablist pressures on students to complete work in set amounts of time, and other conditions that determine different team members' experiences, this close study of empathy may be limited in its impacts.

We agree with these sentiments. Davis' organizational model of empathy calls attention to "Antecedents" that precede and inform empathy's use and manifestation in situ, including the *Situation*. In future work, we plan to focus on *antecedents to empathy with/for teammates*, including aspects of the Situation (e.g., course expectations, engineering culture).

Conclusion

This study sought to clarify how empathy manifests in engineering teams. We initially brought a four-part framing of empathy types but our data analysis revealed relatively limited explicit use of these empathy types (e.g., perspective-taking, concern) with individual team members. Thus, we shifted our analytic strategy and employed the concept of collective empathy, coding transcripts deductively with a tripartite understanding of collective empathy that differentiated between affective, cognitive, and behavioral collective empathy. Our analyses revealed that this tripartite framework was applicable to the data, as students often discussed 'collective' team considerations (while rarely giving voice to peer-to-peer considerations alone). We hope that this study will inform considerations for promoting empathy with/for teammates and will help facilitate the identification of instructional strategies to better promote students' ability and tendency to empathize with/for members. In turn, we hope that this understanding can stimulate future research focused on how empathy and collective empathy can support more effective engineering design teams, as well as associated research in this domain.

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