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The Development and Growth of Empathy Among Engineering Students

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The Development and Growth of Empathy among Engineering Students

Abstract

Discourse on empathy is growing globally, as is its focus within the engineering community. In the context of engineering, scholars have depicted this interpersonal phenomenon as a necessary skill for effectively communicating, a core component of ethical reasoning, and a key technique for designing to meet the needs of users. However, literature regarding its development within engineering is rather limited, and the literature that does exist is disconnected. Even literature outside of engineering tends to focus on childhood development as opposed to adult development. While the developmental literature may tend to focus on earlier ages (likely because this is when an individual most rapidly develops), the endeavor of empathic growth and development need not be abandoned within post-secondary education. Rather, it indicates that we lack an understanding of the ideal means for empathic development later in one's life.

Given the growing emphasis on the necessity of empathy to thrive as an engineer, engineering educators need to understand the constellation of existing tools and pedagogical techniques to foster empathy within the engineering curriculum. This synthesis piece highlights a variety of educational contexts and pedagogical techniques, each of which we posit are equally salient and mutually supportive for the development of engineering students' empathic skills, abilities, or dispositions. We draw from literature from a wide variety of fields, including counselling, psychology, moral philosophy, psychotherapy, neuropsychology, and engineering education. In sum, we describe five educational contexts and a myriad of techniques that we posit, when used effectively and spread across engineering curricula, will be effective means towards the development of empathy among engineering students.

1. Introduction

In recent years, scholars have paid increased attention to the phenomenon of empathy within the context of engineering. In 2011, Strobel et al. found approximately 20 engineering articles that explicitly "embedded the concept of empathy."[1] Yet, a January 2016 search of ASEE's conference proceedings alone indicates that 69 articles explicitly used the term in 2015, 38 in 2014, 23 in 2013, 17 in 2012, and progressively downwards. It appears that empathy is slowly becoming a core focus among engineering education researchers and educators. While this explicit focus on empathy has become widespread more recently, Strobel et al.[2] found that concepts associated with empathy (e.g., users' needs, humanitarian engineering) have had a wide presence in engineering literature. In other words, across engineering literature, empathy has perhaps been an important aspect for some time, although the usage of the term has been rare.

A review of engineering education literature utilizing the term "empathy" suggests that it has broad applicability within the context of engineering education and practice. Scholars' foci in ASEE articles published in 2015 ranged from incorporating empathy within design[3,4], to community engagement efforts[5], to the role of empathy in innovation[6] and entrepreneurship[7]. Furthermore, scholars have indicated that empathy is intimately linked to a number of abilities or activities important for engineers, such as communicating with others[8], developing effective solutions to help community partners[9], and reasoning through ethically challenging issues[10].

Therefore, several scholars have argued that engineers *need* empathy in order to conduct their work effectively.[2,11,12] This sentiment also resonates with practicing engineers who have indicated that empathy and care were especially pertinent within the relational aspects of engineering work.[13] Additionally, scholars have shown that empathy can lead to innovation[14], and others have argued that empathy is necessary for ethical decision-making within engineering[10]. In sum, it appears that promoting empathy within engineering would also improve already widespread efforts.

Nonetheless, as the body of engineering education research on empathy grows, so does the range of proposed techniques for incorporating empathy into engineering curriculum. Engineering education, as a scholarly research community, is a relative newcomer to the field of empathic development, so it is important that we strive to learn from practices outside of the existing body of engineering and engineering education knowledge.

The objective of this paper is to explore literature pertaining to empathic development, growth, or formation throughout scholarly literature from the fields of engineering education, human-centered design, counselling, social psychology, moral philosophy, and neuropsychology. By integrating theories and findings from this diverse and wide range of fields, we seek to provide a defensible position to the question, "What **educational contexts** and **pedagogical strategies** provide the necessary conditions and guidance for engineering students' empathic development and growth?" We do not provide our own empirical data to defend this position, but rather, we rely on the body of existing literature that we seek to integrate. Thus, we aspire to identify a series of strategies that engineering educators may use concurrently or sequentially throughout a student's academic career and which researchers can use as a guide for exploring the development of empathy among engineering students. However, before we do this, we first must conceptualize this multi-faceted and complex phenomenon.

2. What is Empathy?

Empathy is a nuanced phenomenon. It has been labeled as a construct, ability, skill, disposition, intellectual virtue, and much more. According to Batson,[15] there are eight distinct concepts that scholars have called empathy, each of which merits distinction. Batson described the first of these concepts as "knowing another person's internal state, including his or her thoughts or feelings." The emphasis on knowing another's mind is akin to what some scholars have called "empathic accuracy"[16,17] or "theory of mind."[18] Batson described the second as "adopting the posture or matching the neural response of an observed other"; other scholars have called this "motor mimicry."[19] Batson described the third as "coming to feel as another person feels"; this may be described as emotional "catching" or "contagion."[20,21] Batson described the fourth as "intuiting or projecting oneself into another's situation"; this has simply been called projection.[22] Batson described the fifth as "imaging how another is thinking or feeling"; this has been called "imagine other" perspective-taking (as opposed to imagining one's self as the other).[23] Batson described the sixth, a corollary to the fifth, as "imagining how one would think and feel in the other's place." Due to the focus on one's self, this might be described as imagine-self perspective-taking.[24] Batson described the seventh as "feeling distress at witnessing another person's suffering;" Hoffman called this "empathic distress," as the distress was self-oriented but originated from another.[19] Batson described the eighth as "feeling for another person who is

suffering;" this might rather be described as sympathy or empathic concern.[25] Hence, we can potentially reduce Batson's eight empathy distinctions to the following list:

1. Empathic accuracy or theory of mind
2. Motor mimicry
3. Emotional contagion
4. Projection: imagine-self within another's position
5. Perspective-taking: imagine-other
6. Perspective-taking: imagine-self as-if the self was the other
7. Empathic distress
8. Empathic concern or sympathy

Even with these eight distinctions, this list is not comprehensive. For example, *none* of these conceptualizations described empathy in terms of a behavioral response. Batson conceptualized empathy as the motivational source for altruistic action, not the action itself,[23,26] but others, such as Oxley, characterized *true* empathy as involving some form of action.[27] Davis described the *action* as the culmination of distinct empathy types working together.[28] Decety and Jackson, on the other hand, identified the "intention to respond compassionately" as a core component of empathy[29], which is a position that we support.

Nonetheless, Davis posited that empathy motivates action, particularly helping behavior.[28] In particular, Batson[30], Hoffman[19], and Decety and Jackson[29] described affective empathy types to be key motivators for helping others. Further, Hoffman[19] considered perspective-taking (defined as some combination of items 1, 4, 5, and 6 above) to be the most advanced form of empathy (in a developmental sense), which makes it possible to affectively empathize with others not present or with whom one does not know be enabling one to imagine those others. Hence, cognitive empathy may activate affective empathy types when one is not directly interacting with another.

Davis integrated these idea to develop a functional model of empathy.[28] For Davis, empathy's affective forms can be primed either automatically, through the subconscious (e.g. 2, 3, 7, and 8 above), or by empathy's cognitive forms (e.g. 1, 4, 5, and 6 from above). In turn, cognitive or affective empathy types culminate in behavior. Davis theorized that all individuals have varying affinities to utilize distinct empathy types. For example, the likelihood that one will consider another's perspective or become concerned towards another's plight is, from the outset, a function of the individual's affinity for perspective taking, but is not necessarily related to their affinity towards empathic distress. Further, this model incorporated "antecedents" to empathic functioning. For example, Decety and Jackson found that "self-other awareness and self-regulation of emotions" were vital components of "human empathy."[29] Similarly, Batson found that valuing the welfare of another was essential to empathizing with any individual.[31]

Several distinct measures of empathy focus on an individual's propensity to utilize empathy in a general sense (based on how the author defines empathy). For example, Davis[25] developed one of the most prominent psychometric measures for assessing individual differences in empathy, the Interpersonal Reactivity Index (IRI), and this instrument has been used among engineering student populations.[14,32] In the IRI, Davis conceptualized empathy as four unique constructs; perspective taking, empathic concern, personal distress, and fantasy. However, some scholars have criticized the IRI for labeling some constructs as "empathy" that do not fit their definition,

and we would not altogether refute these claims. For example, Baron-Cohen was particularly critical of Davis's fantasy and personal distress scales. In response, Baron-Cohen developed a perhaps equally popular psychometric measure of empathy called the Empathy Quotient [EQ].[33] We would add, however, that the EQ might also be criticized for only evaluating and outputting one score and not differentiating between distinct empathy types (e.g., the eight from Batson[15]).

By integrating this literature, we have developed the following operational definition of empathy: *empathy includes both affective experiences and cognitive processes that may be primed automatically or within the subconscious, and that may operate in isolation or concurrently, but which tend to have a cyclical relationship*. The primary affective experiences include empathic distress and empathic concern or joy whereas the primary cognitive processes include perspective taking, as distinguished by imagining one's self as the other and imagining another's perspective. Taken together, these empathy types can be self-oriented or other-oriented; the cyclical process where self-oriented types leads to or inform other-oriented types (or vice versa) we call *pluralism*, a term utilized by Hoffman.[19] Further, affect can lead to cognition (and vice versa). Hence, while some might think "emotion" will only introduce bias into the engineers' decision-making process, we posit that affect is an ever-operating process (albeit, often subconscious), and that affective experiences are central for motivating one to truly understand another through the cognitive empathic processes.

Figure 1 provides an overview of the cyclical relationship between these empathy types. With this framing in mind, we can now consider the ideas of empathic development and growth, as well as how they relate to the concept of formation.

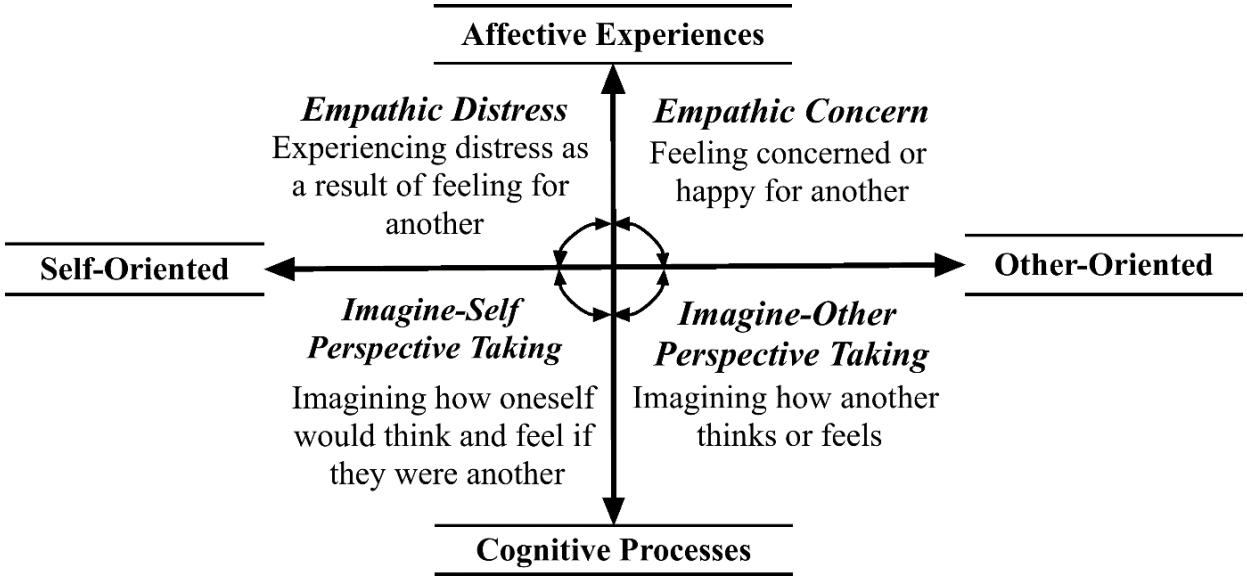

Figure 1. Conceptualizing empathy and the interrelationship between empathy types

3. Empathic Development, Growth, or Formation?

What then are the processes that lead one to become empathic? In a developmental sense, there are numerous *stage* and *schematic* models where one moves from less to more advanced cognitive, social, or moral stages/schema through numerous transitional points. In developmental models from the field of psychology, empathy tends to be a peripheral but important component. For example, many of these models emphasize the individual's cognitive growth as a parallel component to their social development (e.g., Hoffman[19], Kohlberg[34]). Other models integrate all aspects of development into a single unifying staged theory, be it their cognitive/ethical development (e.g., Perry[35]) or their reflective judgement (e.g., King and Kitchener[36]).

Stage models tend to include lower stages or tiers of development that the individual attains in early adolescence. For example, Hoffman developed a stage model of *empathic development*, but this model focused solely on the concept of empathic distress which (he posited), while continually developed throughout one's life, is largely developed prior to becoming a teenager. Perry, on the other hand, focused on the development of college students, but his focus was primarily on cognition (of which ethical development was a part). Similarly, King and Kitchner focused on *epistemic cognition*, or "individuals' underlying assumptions about knowledge and how it is gained." Hence, while King and Kitchner's model did not focus on empathic development *per se*, their "stage 7" thinker was characterized as someone who is open to new perspectives, a crucial disposition if one is to empathize with unfamiliar individuals.

In terms of ethical development, Kohlberg focused largely on the development of (what we would call) cognitive empathy throughout one's life span, and how that influences ethical reasoning. Here, the individual moves from a propensity for considering a "social perspective" that includes solely the self (stages 1–2, egocentric, pre-conventional), to the perspectives of others (stage 3, conventional), to the perspective of a social system (stage 4, conventional), and to a perspective that considers the interrelationships of actors within a system and the system itself (stages 5–6, post-conventional). Kohlberg's model is often juxtaposed against or criticized with respect to interpersonal models of development, such as that offered by Gilligan.[37]

Conversely, other conceptualizations of empathy may support the notion that individuals vary in their propensity for specific empathy types.[28] Notably, this conceptualization has been utilized within engineering.[6,32] Here, we might characterize "empathic development" as something like "growth." Advancement is not a transition from one stage to the next, but rather a process of fostering the tendency for utilizing an existing ability. In other words, we might conceptualize empathic growth as an increase in a propensity for utilizing an existing disposition, whereas empathic development includes the attainment of more advanced or complex stages or schema.

The differentiation between development and growth is important, as with a developmental model, the question becomes, "How do you spark the transition from one stage to the next?" For example, Gilligan suggested that "crisis" provides the opportunity for stage-transition (although she recognized that this does not ensure transition). Conversely, with a growth-oriented model, the question becomes, "How do you enhance an existing skill?" For example, with a focus on perspective taking, rather than trying to "develop" an individual's ability to take others' perspectives, or to reach a propensity for a specific type of perspective taking, the objective might be to enhance the tendency to take others' perspectives. Conversely, the goal may be developing empathy for a specific population, such as an "out-group."[38,39]

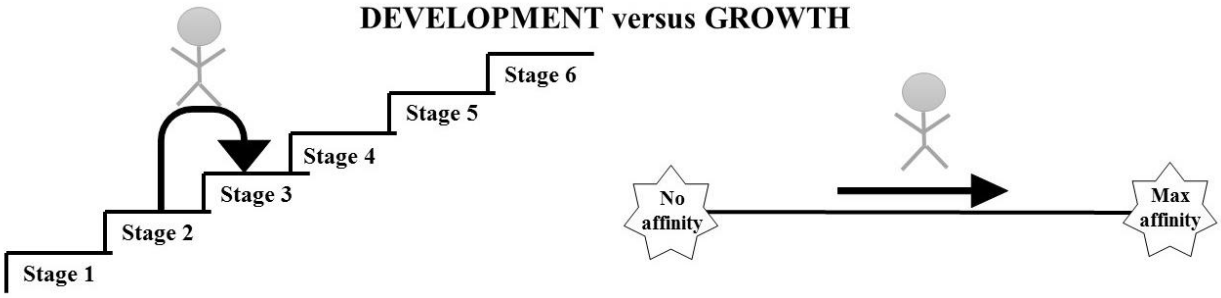

Figure 2. Visualizing development-oriented models versus growth-oriented models

Figure 2 shows our attempt at visualizing the distinction between growth and development. The development-oriented model shows a stair-step progression, whereas the growth-oriented model shows a spectrum upon which one can progress (grow) or regress.

To the best of our knowledge, engineering education scholars have not yet unpacked this distinction when talking about empathy. There is, nonetheless, a push for another related term, *formation*, as evident by the NSF's recent change in the program *Research in Engineering Education* to *Research in the Formation of Engineers*. In their call, NSF conceptualized formation as, "The formal and informal processes and value systems by which people become engineers."[40] Here, they characterized formation as a holistic process where the learner acquires a range of knowledge, value, or skills that are intimately interwoven.

Sutphen and de Lange[41] differentiated between formation and socialization. Specifically, they suggested that the latter "describes how we become a part of social entities" whereas the former "illuminates the ways in which we gain an awareness of our own participation in these social constellations." Hence, empathy may be "grown" alongside an engineer's professional formation as they attain and become aware of other related engineering abilities, such as communication or human-centered design techniques. For example, one might theorize that by improving engineering students' listening skills, an educator will simultaneously cultivate their students' awareness of the role of empathy in these processes, thereby leading to a greater affinity for utilizing pre-existing empathic skills. We encourage engineering education researchers to continue unpacking the distinction between development, growth, and formation to further refine and elucidate these terms.

4. Educational Contexts

In this section, we describe a series of educational contexts and accompanying pedagogical techniques that educators may utilize or have utilized for motivating the development and growth of their engineering students' empathic tendencies. We identified these contexts and techniques by reviewing scholarly research inside and outside of engineering education, through extensive conversations at engineering and design conferences over the last few years, and through dialogue between the authors. In total, we describe five educational contexts (see Table 1). We do not posit that any of these contexts are the most important for developing empathy, nor that this list is final. Rather, we posit that each of these areas provide unique opportunities for fostering students' empathic growth or development. This list is preliminary, and we expect that it will continue to grow in complexity as we, the collection of engineering education researchers, continue exploring the role of empathy within engineering and engineering education.

Table 1: Engineering educational contexts and techniques for developing or growing empathy

Context	Examples of Pedagogical Techniques (Framed as Student Action)
Design Thinking	Utilizing empathic design techniques with an open, user-centric mindset
Service-Learning	Working on real-world projects oriented towards helping others
Communication	Establishing and refining core communication skills, such as listening
Collaboration	Developing conflict resolution and team building skills
Ethics Education	Working through ethical issues by reasoning from stakeholder perspectives

In the following sections, we provide an overview of key literature that has explored the respective contexts from Table 1, along with salient pedagogical strategies for inculcating empathy with respect to each educational context.

4.1 Design Thinking

Two prominent leaders in empathy training for design thinking include the d.School from Stanford University and IDEO, A Design and Innovation Consulting Firm. The d.school developed a series of activities for guiding the use of empathy, such as an *Interview for Empathy* and *Prototype for Empathy* (see http://dschool.stanford.edu/use-our-methods/). Likewise, IDEO created a 51-item card deck where each card represents an empathic design technique (see https://www.ideo.com/work/method-cards). Similar techniques cross both groups, such as *Extreme User Interviews* (identify users who have no prior knowledge of an artifact, ask them to interact with it or utilize it, and observe these interactions) and the *Five Why* root-cause analysis method (ask why until you get to the root cause of an issue). These techniques seem to presuppose that empathy is inherent to the task. Their foci are less on developing or growing empathy and more on becoming aware of how to apply one's pre-existing empathic abilities.

Within the context of engineering design (as opposed to design more generally), a similar focus on utilizing empathy through a variety of techniques is growing. For example, Gray and colleagues developed an *empathic walkthrough* that "stimulates empathy on the part of the student for the design context within which they are working, resulting in a richer narrative that foregrounds problems that a user might encounter."[3] They utilized a three-step sequence where designers (a) walk through a user's story, (b) list and group concerns relevant to the user, and (c) perform a structured ideation task by utilizing an extensive set of design heuristics[42,43]. Throughout the empathic walkthrough, these educators continually prime the learner to consider the user perspective, thereby promoting and reinforcing empathy, namely, other-oriented perspective taking.

While specific design approaches may emphasize the importance of empathy, this does not suggest that empathy is limited only to a sub-group of design practices. Rather, we posit that any projects where designers interact with or design for others (which, we would argue, is most design projects) are suitable for empathic utilization and, thereby, empathic growth. Design tasks where the user is highly visible are likely to manifest in a greater utilization of empathic techniques among designers. For example, Fila and Hess explored the empathic techniques naturally utilized by designers in two settings: a service-learning course[6,44] and a

decontextualized design task[45]. Through these investigations, these scholars identified how the nature of the design task inhibited or promoted the designers' use of empathy. Their findings indicated that designers who participated within the service-learning course and who had the opportunity to interact with users utilized a wider variety of other-oriented empathic techniques (both affective and cognitive) within their design approaches when compared to designers who worked through a decontextualized design task. This latter group relied primarily on self-oriented techniques (e.g., imagine-self as user). Therefore, lacking user interactivity, it seems that empathic design strategies are less effective; specifically, they may fail to promote empathic accuracy (or an accurate empathic understanding) of a user's needs and, perhaps worse, they may give the designer the false impression that they understand the user.[17]

Nonetheless, role-playing or projection activities can be useful for boosting creativity. For example, in the book *Wired to Care*, Patnaik[46] provides numerous examples that highlight how designers within innovative firms perform a myriad of activities to get into the users' shoes, literally. For example, one of the designers Patnaik describes transformed herself into an elderly individual and spent a day in this state; another wore gloves to reduce sensitivity while preparing dinner. According to Patnaik, this is a type of reframing and enables an engineer or a company to look at itself from a customer vantage point, which thereby leads to the identification of unique business niches. Similarly, Johnson and colleagues[47] compared the creativeness of students who engaged in an *Empathic Experience Design* (EED), where they were primed to imagine one's self as a user, with control students who did not have this prompt. Their findings indicated that EED students developed solutions that were more original than the control group.

In the majority of design pedagogical techniques that discuss or feature empathy, there seems to be an inherent assumption that empathy is relevant throughout multiple aspects of design. However, some educators have described an important empathic requisite or antecedent: designers must adopt a user-centric mindset. For example, Postma et al. discussed moving design students from an "expert" mindset, where the designer thinks they know best, to a "participatory" mindset, where the designer perceives their self and user(s) both as experts.[48] Forming this mindset is important, as student designers who hold an *expert* mindset tend to exclude their project partner throughout a design process.[49] Hence, educators ought to prompt students to think about engineering *with* a user as opposed to *for* a user[12,50] as this may catalyze the utilization of empathy while simultaneously alleviating absolutist/positivistic biases.[41]

4.2 Service-Learning

Another salient context for empathic development is service learning, sometimes alternatively referred to as helping initiatives or community-engaged pedagogy. Researchers exploring these contexts do not always focus on empathic development, although when they do, they generally emphasize that these educational contexts provide unique conditions (namely, repeated interactions with users) that support utilization and development of empathy among students toward a specific user group. Generally, the greater the extent or amount of interaction a designer has with a user or user group, the better.[51] For example, Zoltowski, Oakes, and Cardella[52] found that students who immersed themselves into the world of a user were more likely to reach the highest level of human-centered design (which they characterized as empathic design). At this

level, designers sought to develop a strong connection with a user and to understand a user's needs in light of a user's daily life, wishes, and aspirations.

Likewise, in a course titled "Engineering for Humanity," where students observed and interacted with elderly community partners, Lynch and colleagues[53] found that students who initially lacked empathy for their elderly project partners had a transformed understanding of this user group by the end of the course. Most notably, students had two key shifts in their empathic understanding of this user group. First, they moved from "viewing older adults *generically*" to viewing adults as "individuals." Second, while students entered the class with "caricatures in their minds of older adults" such as being "grumpy", they ended the course with an understanding of the circumstances in a user's life that may have influenced that individual's dispositions.

These findings resonate with Delve and colleagues'[54] Service Learning Framework. Specifically, these authors posited that service-learning experiences could encourage students to transition through five phases of service learning development. They characterized a Phase 1 student as "eager to **explore** new opportunities" but someone who had not yet connected "psychologically or emotionally" with a community. Conversely, their Phase 3 learner had **realized** "what the service-learning experience is all about." Lastly, their Phase 5 learner was someone who had **internalized** the service learning experience and had begun to make significant lifestyle changes, such as committing time to the community. Internalization sparks a specific type of empathy; empathy targeted at the community with whom the learner has engaged and now considers one's self as part of (although, we must reiterate, these scholars did not use the term empathy).

Nonetheless, some service-learning pedagogical approaches are explicitly oriented towards growing or developing empathy. For example, Schneider et al. emphasized that community-programs must actively cultivate students' empathy for their community partners or else risk repeating a "history of development, with its colonial and post-colonial implications."[9] Empathy, they indicated, ought to be developed for not only the individuals within the community, but the community as a whole. To accomplish this end, they developed an *Engineering to Help* initiative. They preferred the term "help" to "service" or "charity," as they felt the latter terminology may (unintentionally) promote a perspective that the community partners are "less-than or inferior" to an engineering or design team. They suggested that empathy can only truly be developed by "re-envisioning a community not exclusively through the lens of what it lacks but through its multiple social, cultural, and other assets and capacities, and most of all, its own dreams and aspirations." Hence, they argued that immersion within the community is necessary for the development of empathy for the community, as is (again) adopting a mindset that de-emphasizes one's prior knowledge in order to develop an unbiased view and holistic understanding of a community's true needs.

4.3 Communication

Effective communication skills are an essential component of utilizing empathic design techniques to understand users' needs, within or outside of service-learning contexts. Walther, Miller, and Kellam[8] developed a series of four modules for cultivating empathic communication skills among engineering students. These modules included (a) a direct focus on improving

specific communication skills such as talking, listening, and observing, (b) role-playing activities, (c) reflective writing exercises, and (d) "rich picture" exercises where students consider the potential outcomes for a stakeholder resulting from a design solution. Walther and colleagues emphasized the importance of embedding these modules within engineering courses to avoid students' perceptions that empathic communication was something outside of engineering. Further, they sought to reinforce empathy by having it "infused throughout the course" and continually role-modeled by each of the instructors.

Outside of the context of engineering, Erera[55] developed an Empathy Training Program (ETP) with the goal of enabling helping professionals (e.g., social workers) to understand clients' needs. The ETP is a four-stage process akin to empathic design research methodologies.[56] In ETP, the learner records interviews, develops hypotheses about a client's statements, develops hypotheses about a trainee's statements, and then seeks to verify these hypotheses. Erera indicated that the "function of the hypothesis construction and analysis is to systematically 'enter the client's shoes.'" Hence, the ETP focuses almost exclusively on the concept of *theory of mind*; a completely depersonalized logical process where one attempts to deduce the aims and goals of another mind.[18] This is because Erera's theoretical basis was that techniques, which focus on the user's thoughts, could enable one to generate an in-depth understanding of a user while avoiding arousing anxiety from the social worker. As a result, Erera posited that this would enable the professional to "transform their inhibited energy into a constructive learning experience." Notably, this idea resonates with Decety and Jackson's emphasis on the necessity of emotional regulation for developing an empathic understanding of another, although Decety and Jackson also recognized the importance of affect for true empathy.[29] Hence, while Erera's ETP offers a structured system for analyzing discourse through the collection and analysis of interviews, it does not inform how one might utilize empathy in direct face-to-face conversations, nor (as Erera recognized) how emotions or gestures may influence one's understanding of another.

Perhaps the most prominent discourse on empathy and communication in face-to-face contexts is from Carl Rogers, specifically within client-therapist relationships.[57] According to Rogers, the therapist must recognize that it is *the client who* understands their self, specifically, "what hurts, what directions to go, what problems are crucial, what experiences have been deeply buried."[58] The challenge for the therapist is to elicit this self-understanding, and this eliciting process requires an attentive, empathic, and client-centric focus, rather than a reliance on abstract scientific theories. Further, it requires attention to the clients' emotions and gestures (which, anecdotally, is why many research purists have criticized Rogers).

It is worth noting that Rogers distinguished between research and therapy. For Rogers, the former relies on an attempt for detachment and objectivity, thereby "applying all the elegant methods of science to determine whether I have been deceiving myself." Conversely, therapeutic relationships (and communication within those relationships) rely on some level of subjectivity. Rogers provided several suggestions for developing empathic understanding in such subjective contexts, many of which emphasized introspection. For example, according to Rogers, listening to the *self* was as equally important as listening to *another*, as was the courage to expose one's self to another. Further, effective communication requires that one does not deceive another with respect to one's own thoughts or feelings. One must "*permit*" one's self to understand another

and to "*accept*" another (Rogers' emphases). Other recommendations from Rogers included trust your experiences, look for the best in others, and expect changes in life (our paraphrasing).

Some engineering education scholars have described similar communication skills, such as listening. Leydens and Lucena[59] called listening the "missing dimension" of engineering curricula. Hess's interviews with practicing engineers support this assertion.[60] In this study, Hess cited a practicing engineer who felt that only through experience could an engineer realize the importance of listening. As the engineering respondent stated, "A young, immature person typically believes empathizing with them [other people] means that you have to agree with them. It doesn't, it means that you listen to and respect their opinion."

Leydens and Lucena suggested that a lack of formal training on listening within engineering education leads to the cultivation of an engineering bias where "the human component" of engineering is "marginalized" in favor of abstractions.[59] As a result, engineering students often feel they know what is best and may see "no need to listen to or understand" a user or partner. They suggested that educators need to develop engineering courses that focus specifically on listening, and that they ought to connect these initiatives to case studies or real-world projects. Further, these scholars indicated that situated writing practices, where students reflect on their experiences in "authentic contexts," would inculcate a greater appreciation for a stakeholder's viewpoint. Work on such initiatives may extend the empathic communication framework developed by Walther et al.[8] or Rogers' client-centered therapy.[57] Nonetheless, as evidenced by Rogers' work, communication is a two-way street. Hence, communication frameworks that engineers can utilize to engage in a "symmetric and dialogic conversation" with the community and the public need to be utilized within academic contexts and refined based on the outcomes of such interventions.[61]

4.4 Collaboration

Beyond empathizing with a client, engineers can utilize empathy to establish better relationships among colleagues. In Strobel and colleagues' synthesis of engineering literature, they uncovered two empathic "like-terms" that captured this sentiment: "solidarity" and "build trust".[2] Similarly, Stephan and Finlay discussed the role of empathy in improving interrelationships between groups in professional settings, particularly when those two groups are at odds on an issue or are from different workplace groups.[62] These scholars discussed the long history of conflict resolution workshops and their explicit focus on fostering empathy to alleviate discrepancies between such groups.[63-66] For example, Fisher stated, "Conflict analysis requires clear and honest communication in which parties remain sensitive to common errors in perception and cognition and develop [an] empathic understanding of each other."

One of the largest difficulties a leader must overcome if they are to build solidarity between (perceived) distinct workplace groups is helping workers overcome group biases, whether conscious or unconscious.[38] Stephan and Finlay[62] suggested that developing empathy for members across groups can help improve workplace inter-relations, but emphasized that designers of such training programs must have an awareness of potential issues from the outset. For example, if an employee perceives their workplace peers as *outgroup* members, the training must introduce strategies for enabling the employee to recognize similarities between groups. In

addition, they recommended that carefully selected guided questions that prompt a colleague's perspective could make perspective taking across groups seamless. Next, they suggested that starting a dialogue between colleagues could catalyze an open-mindedness and acceptance of cross-group differences. Lastly, Stephan and Finlay cautioned that empathy training can have unintended and sometimes undesirable outcomes, potentially leading to a distancing between groups. Hence, they recommended that leaders introduce empathy in ways to "blunt its [potential negative] impact." Due to these potential negative effect of empathy training, Stephan and Finlay recommended evaluating changes and monitoring the effects of such workplace interventions.

The focus on conflict resolution emphasizes how a *lack* of empathy can be detrimental to workplace collaboration, but does not discuss how empathy operates within groups who work well together. One essential component (already discussed) is listening: teams that work well with one another tend to listen to one another.[67,68] Yet, beyond listening, there seems to be no limit of effective team skills related to empathy. For example, some scholars have focused on social intelligence[69] and social perceptiveness[70], or one's affinity for perspective taking and their ability to comprehend the perspectives of others when doing so. Another example might be described as a general openness to novel perspectives. As an example, Borrego and Newswander indicated that within interdisciplinary research groups (e.g., engineering faculty and educational researchers), the team members' receptiveness to perspectives outside of their scholarly domain was a defining feature of their effective collaboration.[71] Similarly, the stage 7 thinker in King and Kitchener's model exhibited such openness.[36] Engineering education scholars can begin developing empathy for effective collaboration among themselves, with their students, and among their students by some combination of conflict resolution techniques, communication training programs, and team-skills training.

Lastly, given the growth of online education and the technological manifestations that allow interaction by virtual media, some scholars have focused on how empathy functions between collaborators interacting online. For example, Nguyen and Canny[72] found that empathy manifests differently in two types of video interactions. When they compared between "head-only" and "upper-body" framing, they found that the latter produced a significantly higher level of "oneness" between collaborators. Further, "upper-body" framing and "face-to-face" interactions increased the likelihood that a perceiver would assist their partner (they used a "pen drop" experiment to support this claim[73]). Hence, being able to see a collaborator's full range of motion cultivated a greater amount of empathy between the two. Nguyen and Canny explained that this is because this mode allows for non-verbal communication in the form of body gestures whereas head-only framing does not. Ideally, they posit, collaborators would move a computer camera back two to three times from normal length, allowing a whole body view. As online education programs continue to proliferate, and as educators continue to integrate interactivity into online courses, educators may heed these suggestions in order to improve online teaming.

4.5 Ethics Education

Many prominent ethical theories emphasize some role of empathy within principle and justice-oriented frameworks[27,74] as well as within ethics of care.[37,75]. Kohlberg stressed the importance of cognitive perspective taking for post-conventional reasoning.[34] Similarly, Hoffman emphasized the relationship between empathic distress and ethical action, theorizing that this

was the key to sparking helping behavior.[19] Fundamentally, these theories touch on separate components of ethics. While Kohlberg's focus was on *reasoning* through ethical issues from a societal vantage point and with respect to concerns of justice, Hoffman's was on the motivational drive to *act* on another's behalf in an altruistic sense. Hess and colleagues[10] sought to exemplify how empathic perspective-taking operates during engineering-specific ethical dilemmas, and argued that considering all core stakeholders' perspectives was a necessary, albeit insufficient, condition for ethical reasoning within engineering (i.e., they argued that it must operate in conjunction with one or multiple ethical theories). Conversely, Pantazidou and Nair[75] described an ethic of care as an underlying ethos that can motivate socially just and environmentally responsible engineering practices.

Scholars who support an ethic of care generally criticize principle-oriented ethical reasoning frameworks for their de-contextualization and abstraction from everyday ethical issues. As Rest and colleagues explained, "Critics of Kohlberg claim that his stage sequence favors abstract, impartial principles over loyalty, friendship, and close relationships."[76] Nonetheless, Rest and colleagues posited that *both* ethics of care and principle-oriented theories are useful, but largely in different spaces of ethics. For example, they considered Kohlbergian justice-oriented models to be relevant in dealing with macro-morality issues that involve societal conflict, whereas they considered personal-oriented models (e.g., an ethic of care) to be more applicable in working through micro-morality issues at the one-to-one level.[76] While this distinction is useful, we would add that that micro and macro issues overlap; as Cotkin indicated, the everyday ordinary decisions (e.g., on the micro scale) can quickly escalate into a macro-disaster.[77] Likewise, macro-level decisions certainly affect individuals at the micro level. Nonetheless, we would posit that the primary role of empathy might be distinct between the two. Macro issues seem to rely largely on cognitive empathy whereas micro issues seem to rely more on affective empathy. As a result, we posit that focusing on the varying empathy types can lead to complementary but distinct pedagogical interventions and outcomes within engineering ethics. Next, we consider the two separate ethical theories (e.g., principle-based versus an ethic of care) and the utility of varying pedagogical techniques with respect to each.

Principle-based models lead to the development of empathy in terms of *breadth*, as ethical principles can lead to empathic deliberation where numerous stakeholders' perspectives become salient to the reasoner.[19,27] For example, to have students consider the principle of justice, an educator might ask, "What is the most fair solution?" This simple framing can lead to the consideration of a variety of stakeholder perspectives whom one may not have previously considered. A common pedagogical technique in the justice domain, theorized by Rawls[78] as a means to ensure that "no one is advantaged or disadvantaged in the choice of principles," is to have students reason through a *veil of ignorance*. In essence, this thought experiment challenges the reasoner to consider the most ethical course of action by assuming the perspective of a stakeholder who holds a random position in society. To be effective, the reasoner must assume a full range of stakeholder perspectives and utilize these imagined perspectives to support their decision.[19] Ethical case studies are one of the most common means of ethics education within engineering.[79] Case studies, combined with a veil of ignorance approach, can provide a unique opportunity to make a wide range of stakeholder perspectives salient to an engineering student.

Engineering educators can also utilize case studies to support an ethic of care.[75] Here, the objective would be to develop a student's *depth* of understanding of stakeholders involved in a case, along with their orientation towards these stakeholders. These objectives could be achieved through multiple strategies. For example, students could be challenged to apply, balance, or prioritize multiple principles from a stakeholder's perspective.[80] Another pedagogical technique is role-play, where students imaginatively embody a stakeholder and reason through the case from that perspective.[81,82] Role-play can enliven moral issues and has the added benefit of grounding theory in a tangible and engaging context. Yet another strategy is narrative accounts of user experiences. Haws described *humanist readings* as a technique that allows "the engineer to see engineering outcomes from the perspective of non-engineers" and further recognized that the student must "interact with these readings in the affective domain."[83] To enable students to emotionally engage with a case, educators might heed the findings from Batson and colleagues' work: simply being instructed to engage in emotional empathy while reading about the plight of others increases empathic responding.[84] Nonetheless, in each of these exercises, we would emphasize that affective empathy may be the focus, but it is not the only type being primed, as the empathy types are interrelated (see Figure 1). As Kidd and Castano[85] showed, reading literary fiction "temporarily enhances" a student's theory of mind as well.

5. Closing Discussion

In this paper, we provided a conceptualization of empathy, we distinguished between the terms growth, development, and formation, and we explored five educational contexts that we perceived to be especially pertinent for the development or growth of empathy among engineering students. Our operational definition of empathy was as follows*: empathy includes both affective experiences and cognitive processes that may be primed automatically or within the subconscious, and that may operate in isolation or concurrently, but which tend to have a cyclical relationship*. We described *development* as an upwards progression between varying stages or schema, *growth* as an enhanced affinity for or ability to apply a pre-existing skill or disposition, and *formation* as the cultivation of varying, related skills that are required to become a professional, such as an engineer, alongside an awareness of that formative process.

We described five educational contexts that we posited were especially applicable for engineering students' empathic development or growth: (a) design thinking, (b) service-learning, (c) communication, (d) collaboration, and (e) ethics education. As a close reading of the separate sections will make evident, pedagogical techniques spanned multiple contexts. That is, most of the pedagogical techniques that we described can be and have been utilized in multiple educational contexts, as highlighted in Table 1. Example pedagogical techniques we identified included (in no specific order) role play, projection, immersion, observation, guided perspective taking, humanist readings, community-specific readings, interviews for empathy, principle application, listening exercises, and reflective writing. Future investigations ought to consider how to apply some of these techniques within novel contexts, as well as which combinations appear to be most effective by exploring the outcomes of students' empathic development or growth resulting from such interventions. Such investigations might use a quasi-experimental research design, similar to Johnson et al.'s investigation of the effectiveness of an Empathic Experience Design on students' originality and creativity.[47] Likewise, they might utilized validated instruments for measuring empathy, such as the Interpersonal Reactivity Index.[25]

While throughout this paper we have focused on contexts and pedagogical techniques that educators can use to develop their students' empathic abilities, we conclude this paper by briefly considering other important parameters for developing empathy among engineering students, including (i) empathic biases, (ii) experience, (iii) internalization, (iv) emotional regulation, and (v) potential unintended outcomes of empathy training.

(i) First, empathy often does not manifest in every interaction one has with another, as humans tend to be biased. Specifically, we are biased by our familiarity with others who are more like ourselves (e.g., kin, close friends).[39] However, if individuals can identify similarities between themselves and another, their empathy for that other is likely to be primed, and their affinity for employing empathy targeted at that other will also increase.[86] Further, empathy is more likely to be automatically primed when another is present. In other words, we tend to empathize with individuals who are *here now*.[19] The old idiom, out of site out of mind, rings especially true here.

(ii) Second, empathy must be consciously experienced by the individual. The quantity and duration of experiences depends on the criticality of each, so contextualizing empathy in authentic and meaningful experiences is crucial for supporting empathic development. An individual may be unknowingly biased towards or against consciously experiencing empathy, so additional pedagogical measures may be necessary for making such biases apparent and to help individual students find commonality between themselves and others.[62]

(iii) Empathy (like any disposition) is likely difficult to change.[87] Nonetheless, there are ample studies that show empathy can be developed or grown among students, including adults.[60,86] Nonetheless, we posit that empathy will only be internalized by an engineering student to the extent that a student reflects on and finds purpose or value in incorporating empathy into their mode of being.[54] Thus, empathic experiences must be made meaningful to students at an intrinsic level; critical and immersive experiences seem especially important in this respect.[37,52] Further, students must have sufficient opportunities to reflect on their experiences in order to make empathy intrinsically important.

(iv) Empathizing with another is contingent upon the ability to regulate one's emotions when considering another's.[29] If one becomes overly distressed, they tend to focus on their own perspective rather than another's.[19] Pluralistic cognitive empathy requires a complex mental juggling act of sorts where one navigates from a self-perspective, to another's, and back to the self. Further, the individual needs to recognize that the two perspectives are not one in the same. When over-distressed, the empathizer may lose sight of another's perspective due to their cloud of egoistic despair. Educators seeking to cultivate empathy must be cognizant of over-distress and attempt to alleviate situations leading to this.

(v) Empathy training can have unintended outcomes. Stephan and Finlay described how empathy training might unintentionally lead to a broadened gap between groups that one perceives as distinct.[62] Likewise, Walther et al. discussed how engineering students might perceive empathy as something outside of engineering practice,[8] a similar finding elucidated from student interviews conducted by Fila and Hess[88]. Our suggestion is to use active pedagogies. For example, allow students to interact with real-world users and to reflect on how empathy operated throughout those interactions. This first-hand experience will (ideally) alleviate issues

accompanied by simply talking about the theoretical utility of empathy in a lecture-style format. We posit that service-learning contexts provide sufficient conditions for such development, as described by Delve and colleagues.[54]

6. Future Research

Future investigations might explore how participating in some of the aforementioned contexts affects students' empathic growth or development. For example, researchers might explore whether engaging in community-oriented or service learning projects impacts students' empathic dispositions by using applicable pre/post psychometric measures. Further, researchers might compare these outcomes with those of students who participated in a "traditional" engineering curriculum dominated by engineering science courses that feature, primarily, closed-ended and de-contextualized problem solving. Similarly, in the future, researchers might focus on the directionality of empathy resulting from any of these interventions, such as how a community-engaged pedagogy supports students' empathic affinities directed towards community partners, versus one's colleagues, and versus the community as a whole.

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