AC 2012-4456: EMPATHY AND CARING AS CONCEPTUALIZED INSIDE AND OUTSIDE OF ENGINEERING: EXTENSIVE LITERATURE REVIEW AND FACULTY FOCUS GROUP ANALYSES

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Empathy and Caring as Conceptualized Inside and Outside of Engineering: Extensive Literature Review and Faculty Focus Group Analyses

Abstract

The purpose of this study was to investigate how faculty both inside and outside of engineering conceptualize empathy and care and how they perceive empathy, care, and engineering to be (or not to be) interrelated. The project employed a comprehensive comparative literature review alongside a thematical analysis of focus group interviews, the interviews being conducted with faculty inside and outside of engineering. The primary research objectives include (1) defining empathy and care within engineering, (2) defining empathy and care in disciplines which are traditionally perceived as caring/empathetic (e.g. counseling, nursing, etc.), and (3) comparing the role of empathy and care within engineering to disciplines outside.

This study found that the terms "empathy" and "care" are infrequently applied to an engineering context, although like-terms such as "users' needs" and "compassion" are present in the literature. Focus group participants discussed several ways through which engineering is already an empathetic/caring discipline, such as in the prominence of collegial collaboration or when considering the importance of the societal issues engineers seek to solve. It was suggested that if engineers were to become more empathetic and caring diversity may increase and solving people's problems would become more prudent. Using the literature review and thematical analysis as way points, implications for the education of engineers and engineering as a profession are discussed. Overall, promoting the constructs of empathy and care in engineering education was considered a positive undertaking with numerous implications.

Introduction/Background

Empathy is one of the most powerful emotions, yet until recently society and science have ignored "the *most valuable resource* in our world".[1] The last ten years have seen an increase of research articles and popular books on the topic of empathy. For example, titles such as "Mirroring People: The Science of Empathy and How We Connect with Others"[2] and "The Social Neuroscience of Empathy"[3], both published in 2009, represent two recent examples of the growing body of the newly emerging "science of empathy". By a cursory and unsystematic review of the literature (this paper will present a much more thorough review), the lack of research on the connection between engineering (along with other technical/scientific fields) and empathy/care is glaring. This comes as a surprise because *empathetic design* is considered the most comprehensive form of human-centered design[4] and *empathic communication skills* are postulated to lead to more personal connection to stakeholders:[5] As the world becomes more integrated culturally and environmentally, engineers have to adapt to challenges with responsible innovations that embrace ethical and ecological contexts. Traditionally, engineering as a profession has focused primarily on a set of technical skills, such as problem solving, design, and modeling. It is undeniable that these skills are core and important. However, the target attributes for future engineering graduates, such as featured in the National Academy of Engineering's (NAE) "Engineer of 2020", include specific character qualities and affective dispositions as well,

wherein promoting traits such as empathy and care is sometimes referenced as *holistic engineering education.*[6]

The NAE now emphasizes the need to promote engineering "habits of mind", which include systems thinking, creativity, optimism, collaboration, communication, and attention to ethical considerations.[7] These "habits of mind" qualities would shift perceptions of engineers from individuals who are solely object-oriented workers to individuals who have a strong work ethic (in collaborations and communications), are ethically responsible (globally, socially, intellectually, and technologically), are able to adapt to new trends, are innovative, and are entrepreneurial. Research in other domains such as medicine and nursing found that traits which underlie many of the attributes for the NAE's idealized "Engineer of 2020" (as similarly desired for the medical profession) are empathy and care.[8]

Despite NAE's initiatives, there is a lack of research and curricula on the development of habits of mind, including empathy and care, in engineering education. Although other disciplines incorporate empathy and care as part of long standing core values and learning outcomes, little of this expertise has made its way into engineering and engineering education.

Historically, the engineer has had a masculine image,[9] which is associated with keeping emotions to oneself or actively hiding feelings in order to be perceived as objective, impartial, analytical, and *not* weak.[10] Thus, it is not surprising that when this conversation about empathy and care's relationship to engineering arises, the engineer might say, "Shhh" as these terms traditionally do not mesh with the dominant image of engineering.

The research questions guiding this study are as follows:

1. How, and to what extent, are terms associated with empathy and care being used within engineering literature, and to what aspects of engineering are these terms most frequently related?
2. How are empathy and care perceived to be present within the engineering profession according to the views of engineering faculty representatives and non-engineering faculty hailing from domains traditionally perceived to be empathetic and caring?
3. How are empathy/care currently incorporated into engineering education and are there areas where they may be further incorporated?

We will begin by introducing our theoretical framework, summarizing prior research and existing literature before presenting our study. We will then describe the methodological framework, methods of data collection and analysis, and results. Finally, we will conclude by discussing implications and take-away messages for engineering education.

Theoretical Framework

There are no single universal definitions of empathy or care, nor is there only one means of teaching these constructs. One widely accepted definition of empathy presented by Berger was being able to understand the experience of others.[11] In turn, one shared understanding of caring, as defined by Mayeroff, is helping others grow in their unique way and at their own pace.[12] While empathy and care are often considered to be related (e.g. empathy leads to caring, caring

leads to empathy, one trait is a component of the other), one unanimous consensus on *how they are related* is non-existent.

Empathy is both a cognitive and an affective process. It involves a person's perceptions, thoughts, and feelings and how those concepts become manifested into a deeper understanding of others. Generally, empathy is considered an internal process that may or may not lead to an external expression of conveyed understanding.

Care is a similar complex construct, involving both feelings and actions. It is a concept that dwells in intentions and actions of people who are pursuing the wellbeing of something, whether it is another person, the environment, the general public, the goals of a company, the values of stakeholders, or their own personal interests. Given the wide variety of definitions for care, no two individuals are likely to understand the concept exactly the same.

Analyzing the constructs of empathy and care together allows researchers to gain insight into which specific elements of these broad concepts are the most significant to the world of engineering. It has been posited that empathy leads to care, care leads to empathy, and even that the two constructs are in fact inseparable,[13] we posit that situated *together* and *within* an engineering context, empathy will instill within engineers an affective disposition, whereas care will influence engineers to act in a positive manner. An empathetic engineer will understand which actions are deemed positive to others and a caring engineer will ensure that their engineering decisions have long-term positive effects.

This project is grounded in two theoretical assumptions stemming from *Conversation Theory*.[14] First, in order to conduct interdisciplinary work and integrate conceptions from different fields of inquiry, a common language needs to be established. Second, the establishment of a common language is not a static process or the development of a thesaurus; common language is a continued and dynamic process of negotiation, in which conversations between participants lead to knowledge emergence and shared understandings. Conversations are not merely describing an existing reality: conversations can be understood as practices "that systematically form the objects of which they speak".[15]

Prior Research and Literature Review

This paper is a comprehensive extension to a previous literature review that examined how empathy and care are conceptualized in standards and curriculum of fields that are traditionally perceived to be empathetic and caring, fields that "have mastered the integration of teaching of empathy and caring into their regular curricula".[13] The previous literature review also examined how the terms "empathy" and "care" were being used within engineering literature.

In the previous study, we found 22 empathy and 16 care-related engineering papers explicitly using these terms. Nearly half of these (14 and 7) papers were within the domain of Engineering Education. While empathy and care have been incorporated into many professional standards, such as counseling and nursing, rarely is this the case in engineering. One exception was the American Society of Civil Engineers' "Vision for the Civil Engineer in 2025", which suggested that the future civil engineer should be able to "[l]ead by formulating and articulating environmental infrastructure and other improvements and build consensus by practicing

inclusiveness, **empathy** [emphasis added], compassion, persuasiveness, patience, and critical thinking".[16]

Phase 1 – Extensive Literature Review Research Study

Methodology

Using the engineering literature which used "empathy" or "care" explicitly, we extracted those keywords that were used to define these terms, our goal being to explore how empathy and/or care are incorporated in existing engineering literature by employing like-terms. We next generated an "alternative keyword" list and then excluded vague terms from this list. The final list of like-terms that we explored extensively are *build trust, compassion, helping profession, humanitarian, humanized, safety, solidarity, community involvement* and *users' need.* Using these, we conducted a literature search using engineering literature databases such as IEEE Xplore and Compendex (Engineering Village), which also index the major publications of engineering education.

We analyzed these papers through a summative content analysis approach where we began by "identifying and quantifying certain words or content in text with the purpose of understanding the contextual use of the words or content". (p.1283)[17]After identifying articles that employed the aforementioned keywords, we next analyzed how these words were defined in our collected references. We opted to focus on papers in which the keywords were explicitly defined, rather than papers in which the keywords were simply used. Table 1 shows the number of papers we collected and analyzed paired to a given keyword.

Table 1: Summary of Articles Found

Keywords	Number of papers collected	Number of papers analyzed
Build trust	13	7
Compassion	9	6
Helping profession	7	3
Humanitarian	27	9
Humanized	9	3
Safety	19	7
Solidarity	9	5
Community involvement	8	5
User's need	12	4
Total number	**113**	**49**

Phase 1 Results and Discussion

Although the terms "empathy" and "care" are infrequently explicitly used in engineering literature[13], "alternative keywords" have a larger presence. The context of these terms varies largely between discourses on *engineering practice* versus *engineering education*. Some of the associated terms, such as "humanized" and "user's need", are used exclusively in the engineering

practice literature, while other terms, such as helping profession, appear more frequently in engineering education literature.

Engineering Practice

Build Trust

Bandow explored how trust was defined by members from dispersed work groups working in complex systems development. Bandow indicated that trust included "elements of verbal and nonverbal; commitment; follow-up and consistency of group members; honesty; communication; competency; intent; common understanding; personal relationships outside of the workplace". (p.163)[18] Derro & Williams summarized the competencies and associated behaviors of highly regarded systems engineers at NASA, seeing "trust of self and others as a pervasive element required to achieve success" (p.11)[19] and the actual behaviors to gain respect, credibility and trust include: "Uses respectful tone, words and body language"; "Follows through on commitments and serves as an advocate for the team"; "[U]nderstanding and appreciation of the challenges others face"; "[D]emonstrating personal integrity"; "Conducts business in an honest and trustworthy manner…"; "[T]reating team members fairly"; "Sees trust of self and others as a pervasive element required to achieve success"; "[H]aving a strong understanding of the system's technical requirements and assigns work based on individual's skills and abilities"; "Lets team members do their job". (p.11)[19]

Compassion

Effective engineers must understand "how technical solutions will fit into context; this requires a level of understanding and compassion for those who will benefit from engineering design activities". (p.S1B-8)[20] Moriarty and Julliard expanded the notion of compassion as a virtue ethics for engineers, ranging from care for individuals to care and compassion for processes or products.[21] Within this frame, they argued that the choices an engineer can make are always "a combination between objective criteria and subjective reflection" (p. 182f) and that the best product would be designed "in the sense of care and compassion for the other in a social context". (p.183)[21]

Humanitarian

Humanitarian engineering is "a balance of technical excellence, economic feasibility, ethical maturity, and cultural sensitivity". (p.1)[22] It requires engineers to "design under constraints to directly improve the wellbeing of underserved populations". (p.2)[22] These constraints might be "not just physical and economic, but also environmental, legal, political, cultural and ethical". (p.2)[23]

Haselkorn believed that engineers should apply their skills to the needs of the humanitarian sector, from "helping to establish an effective and sustainable infrastructure to helping provide food, shelter, and improved medical care". (p.325)[24] Additionally, engineers should not develop isolated technical solutions but engage in "much wider system strategies that consider and address the full sociotechnical context of humanitarian problems". (p.326)[24] Likewise, Vallero and Visilind see empathy as a virtue that guides engineers to become more socially responsible.[25]

There are engineering organizations that focus on the humanitarian efforts of engineering. For example, "Engineers without Borders" and its many national and regional branches "aspires to help integrate cultural, political, social, economic, and environmental contexts into technology, and to use technology for the service of human development". (p. 13)[26]

Humanized

Humanized design has "drawn a great concern within contemporary design trends", originating from a "focusing on the needs of human-being in modern age". (p.1)[27] Zhang, Shang, Yu, Li and Zhao regarded humanized design to designing something by "exploring human nature and application of human behavior, abilities, instincts limits and other characteristics and to create a good human-computer interaction". (p.1079)[28] In humanized design, the designer should take "the fulfilment [sic] of basic function" and "the parameters which referred to physiological, psychological, behavioral and cultural factors" into account. (p.2)[27]

Safety

It's consistently noted that the design of engineering products should take users' safety into consideration.[29,30] Engineers should also pay attention to safety accidents that occur during their work.[31] Thus, and not surprisingly, safety is central to many engineering design processes and manufacturing procedures.

Solidarity

Hovmark and Nordqvist proposed that "teamwork and group solidarity are crucial for project success". (p. 393)[32] Unger suggested that lack of solidarity leaves engineers "exposed to career damage" (p.7)[33] and Lynn found that Japanese engineers show solidarity by staying "late at the office" with their co-workers. (p.474)[34]

Community Involvement

Research shows that community involvement projects have been carried out in many places, to help the local people solve a pressing need.[35,36] Local residents can be involved in the projects by participating in surveys and interviews conducted by engineers.[37] Prior work indicates that community involvement can happen "at all levels of the product-development process",(p39)[38] from "needs-identification process to brainstorming to concept evaluation to prototype testing, and then to the evaluation and iteration processes". (p.39)[38] The absence of community participation would result in the loss of "opportunities for working towards social justice". (p.40)[38]

Users' needs

The majority of the literature we found indicated that engineering products should be designed or produced in the way that satisfies users' needs, and that users' needs should be identified in the early stages of design.[39,40] Various techniques, such as interviews, scenarios, and questionnaires

can be used in order to elicit what these needs are.[41] During the user requirements stage, "different types of user" and "the results to be delivered to them (users) in terms of capabilities and constraints" should be defined. (p.428)[42]

Engineering Education

Build Trust

Building trust is regarded as one of the "baseline non-technical skills for team members" (p.433)[43] that should be taught in engineering education. Taran and Carter,[44] Mee and Teune,[45] and Robillard[46] indicate that trust is central to team collaboration in most professions. Taran and Carter state, "Becoming worthy of trust and learning to trust are active processes that require the participants to communicate and interact." (p.99)[44] In Morell de Ramirez et al.'s study, in order to build trust among team members, "students are given a seminar on organizational behavior and participate in a number of hands-on activities to expose the newly formed teams to situations that accelerate team cohesiveness". (p.434)[43] Brown, Flick and Williamson suggest that building trust is one of the important components of social capital that should be taught in engineering.[47] They summarized that "development of social capital can be influenced through student focused academic discourse, group processes in the classroom, cooperative learning, service learning, teaching assistant behaviors, and difficult open ended lab activities". (p.S3D-13)[47]

Compassion

Character, like courage, compassion and empathy, is considered as one of the "[a]ttributes of an engineering education that promotes social justice". (p.S3A-2)[48] Burker, De Paor and Coyle indicated that when students recognize that engineering can have a positive impact on the lives of those who are disadvantaged or socially excluded" they "gain a sense of professional responsibility and compassion". (p.36)[49] Burker et al. believed that this sense could be fostered by involving students in "Humanitarian Engineering in Action", which includes "[r]ehabilitation engineering and assistive technology research". (p.36)[49]

Catalano described a unique type of design project called compassion practicum, which "requires students to use an engineering design methodology to identify, design a solution and implement that solution with the charge to the student stated as 'do something compassionate for some being other than you'". (p.S3E-8)[50] Compassion practicum gives students "a chance to do something for some living being" and "demonstrate willingness to make a difference in a positive way in the world". (p.S3E-10)[50] Examples of compassion practicum include: "[w]orking at a local homeless shelter" and "[v]isiting with residents of senior citizen homes". (p.S3E-10)[50] Catalano showed that through these concrete actions students began to understand compassion.[51]

Helping Profession

For the education of engineers, research shows that middle and high school girls are less likely to see engineering as a helping profession. (p.T4D2)[52] Therefore, engineering programs that introduce engineering to middle school and high school students "highlighted engineering as a helping profession with 'real world' applications" (p.S1F-20)[53] rather than a "simply mechanics" and "people who build stuff". (p.S1B-5)[54]

Humanitarian

Humanitarianism is described as "a missing dimension of engineering ethics" (p.4)[55] and humanitarian engineering is defined as "the application of engineering knowledge and skills to communities in need". (p.T2H-24)[56] Many papers talk about integrating humanitarian engineering into engineering curriculum. For example, Skokan and Gosink described the humanitarian engineering education program at Colorado School of Mines, the goal of which was the creation of engineers who are "sensitive to social contexts, committed and qualified to serve humanity by contributing to the solution of complex problems at regional, national, and international levels and locations around the world in need of 'smart' technical assistance". (p.2)[57] Skokan and Gosink also found that women would be drawn more to engineering if humanitarian engineering were more emphasized.[57]

Somerton, Thompson and Haddow's work looked at humanitarian design projects at Michigan State University, believing that those projects could immerse "students in complicated tasks that ultimately help people less fortunate than themselves". (p.2)[58] Berndt and Paterson argued that incorporating humanitarian case study into technical communication courses, for example, would encourage students to "take community into consideration" (p.403) and prompt "higher levels of learning, student engagement and the global citizenship". (p.398)[59]

Safety

Many papers talk about teaching safety issues to engineering students. First, students are expected to understand the risks of engineering products to human safety.[60,61] Second, students should understand that engineering work also contains safety issues since it involves some dangerous conditions such as equipment failure. So they have to work safely themselves and look out for the safety for those working with them.[31] Murphy argued that engineering students should know the safety precautions of their design decisions, and stresses the importance of teaching safety through presentations and site visits.[62] Lutey and Knoll believed that it was important to teach construction safety to students since most faulty construction jobs will lead to loss of human lives.[63]

Solidarity

Yamada posited that "Continuing Engineering Education" must help students develop a "[g]rasp of the group's solidarity". (p.11)[64] Additionally, Ramingwong, Sajeev, and Inchaiwong suggested that "[t]oo strong a team solidarity causes inappropriate protectiveness". (p.69)[65]

Community Involvement

Community involvement is identified as one of the essential characteristics of programs that attract women and minorities to engineering and science.[66] An example of engineering programs that encourage community involvement is EPICS (Engineering Projects in Community Service) which is built on the premise that students develop real-world skills by solving problems based on the needs of a community.[36,56] Such projects can provide students with experiences that

"complement and reinforce classroom and laboratory learning" and "serve to demonstrate social and environmental impacts of engineering solutions". (p.F3E-16)[37]

Overall Findings from Literature Review

The research team was not able to find explicitly literature that put engineering in light of being a "helping profession", nor did we find literature on "user's needs" and "humanized" in the domain of engineering education. It's interesting to note that we are using the term "helping profession" to attract females to engineering, but then not using this language within engineering literature. Likewise, it is curious that while "user's needs" and "humanized" are terms being used in engineering literature, they are not being explicitly promoted as such in engineering education.

The three primary findings of our literature review were (1) *empathy* and *care* as terms are not well represented in engineering literature, but associated terms do have presence, (2) empathy and care seem to be present in engineering practice and education somewhat differently, although teamwork seems to be one common factor, and (3) empathy and care need to be defined and further developed in engineering. Overall, the literature review highlighted that the terms care and/or empathy are infrequently utilized in an engineering context, albeit an overarching agreement that there is a benefit and need to integrate similar terms. As empathy and care have been used alongside these alternative keywords, it seems that empathy and care have an unexplored potential waiting to be tapped into.

Phase 2 – Focus Group Research

Methodology

The focus group component of the study employed a qualitative comparative case study framework,[67] where "insider" perspectives on empathy and care in engineering were taken from engineering faculty and "outsider" perspectives were taken from non-engineering faculty. Noting that "careful attention to case selection is crucial to [a qualitative study's] success",(p.11)[68] taking engineering responses as one case and non-engineering responses as another allows for a comparison of (1) general understanding of empathy and care, (2) mechanisms for teaching empathy and care, and (3) differing viewpoints on how these fit into an engineering context.

Three engineering and three non-engineering focus group sessions were conducted with a total of seven engineering and nine non-engineering participants. Note that the engineering/non-engineering distinction does not represent a dichotomy. Rather, the intent is to distinguish between views of faculty very familiar with engineering and with those less familiar. As Creswell suggests, "Focus groups are advantageous when the interaction among interviewees will likely yield the best information, when interviewees are similar and cooperative with each other." (p. 33)[69] Therefore, engineering faculty and non-engineering faculty were interviewed separately.

Interviews were audio recorded and then transcribed. Faculty focus group interview sessions were semi-structured guided by queries such as, "What does empathy mean and does it have prerequisites", "How empathetic/caring is engineering", and "Do care and empathy have value in your curriculum". For the full list of guiding questions, see Appendix A.

Following transcription of the interviews, a coding scheme was inductively developed through several iterations, a process known as *categorical aggregation*. (p.163)[69] Six coding groups were used to capture themes from the data, the overarching categories being:

1. Where participants direct empathy/care (e.g. towards another single person, multiple people, inwards to oneself, to society or civilization, animals, etc.)
2. How participants defined empathy and its prerequisites
3. How participants defined care and its prerequisites
4. When the discussion does not distinguish between empathy and care, what do participants say about the terms (e.g. big part of their profession, motivation for a project)
5. How participants rank the role of empathy and/or care in teaching and learning
6. The role of empathy and/or care in engineering practice and engineering education

The coding scheme is included in Appendix B.

After one member of the research team (Coder 1, a male PhD student in Engineering Education) finished coding the data and had developed a rigorous coding scheme, a second member (Coder 2, a female Master's student in Counseling with some undergraduate experience in engineering) engaged with the data and (1) agreed or disagreed with the codes paired with data, (2) added codes that were thought to be "missed", and (3) provided comments to support these claims. (Note: the schooling and gender of each coder is mentioned only because each held moderately dissimilar viewpoints, stemming from dissimilar backgrounds, when approaching the data).

The detailed coding scheme allowed each coder to evaluate the transcribed conversation from each focus group and assign each statement a "value" or code. It was possible to code each statement with as many or as few of the codes that applied. This independent process also gave each coder the freedom to assess the statements based on in their previous experiences and current understandings of the provided conversations. Coder 1 initially coded 633 items. Coder 2 used Coder 1's initial results to independently evaluate the statements from the focus groups. Then, Coder 2 suggested 232 additions and 54 removals to this initial pool, giving an initial agreement rate of 91.5% (see Figure C1 in Appendix C).

After reviewing the focus groups independently, the coders compared their results. Throughout the collaborations, it was found that Coder 1 was very conservative in his evaluations, rarely assigning a code to a statement unless the topic of the code was explicitly mentioned; while Coder 2 applied the codes more liberally, evaluating the possibility of deeper meanings or implications behind what the participant was discussing. Coder 1 reviewed the suggested additions, accepting a total of 145 items, and after revisiting the remaining items that Coder 1 believed should not be included, Coder 2 revised her editions and agreed on which items should be removed. The second round of coding produced two new categories (C=E and AexpE, see Appendix B) to acknowledge newly formed understanding and resolution of some of the initial disagreements. The final total number of unsettled disagreements was 81 of a total 778 items coding, giving an overall agreement of 89.6%, which is considered an acceptable to high level of inter-rater reliability[70] (see Figure C2 in Appendix C).

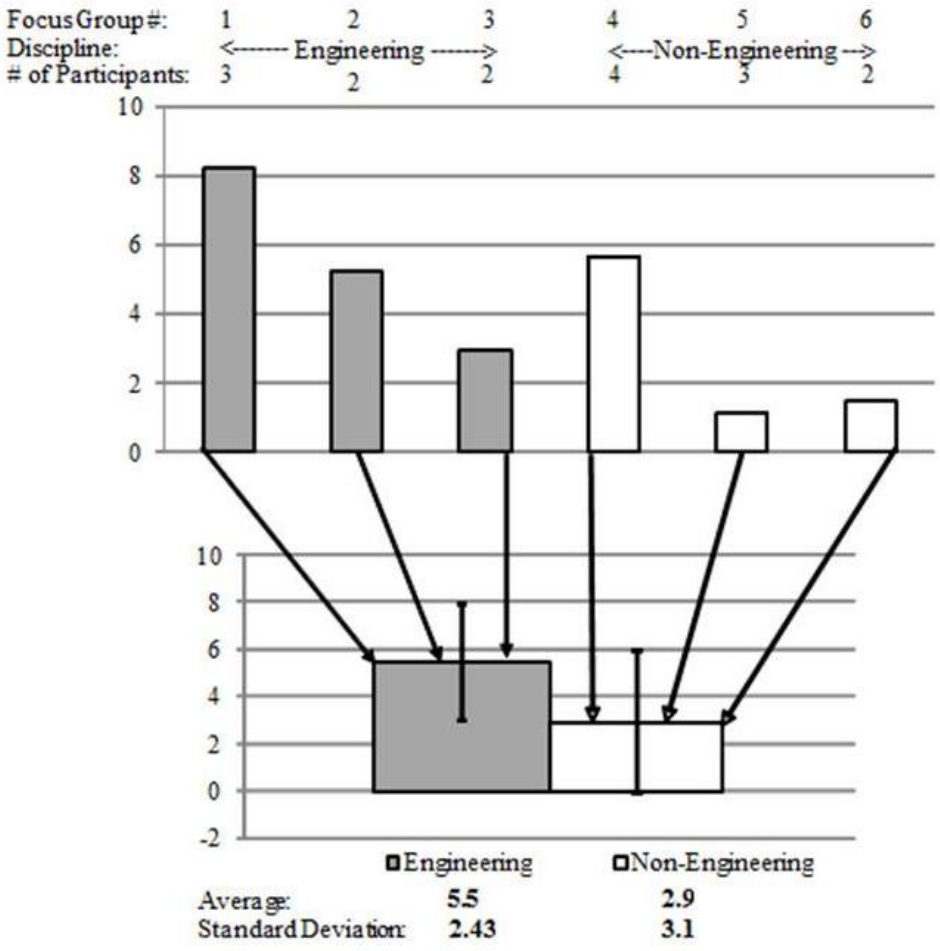
The larger team discussed the findings by the two coders, questioned interpretive decisions and provided input on critical junctions throughout the process.

Phase 2 Results and Discussion

All faculty participants demonstrated some understanding of how empathy and care are defined, although the engineering conceptualization tended to be, unsurprisingly, less reflective and less jargon-rich than non-engineering participant responses. Both engineering and non-engineering participants, at least initially, understood empathy and care to be personal-oriented concepts. That is, a person is being empathetic or caring if he or she is directing some attitude or action towards an individual or a group of people. This idea is related to the previously mentioned widely accepted definitions of empathy and care.[11,12]

Towards the end of each session, participants were asked to rank engineering as being empathetic/caring on a scale of 1-10. There was wide variability in how caring/empathetic participants thought engineering was, as shown in Figure 1. This figure is presented before presenting actual interview responses for two reasons, (1) to highlight the variability in viewpoints and (2) to provide a point of reference when introducing and discussing participants' more nuanced statements.

Figure 1: Engineering vs. Non-Engineering Focus Group
"How empathetic/caring is engineering on a scale of 1-10?"



The top half of Figure 1 shows the focus group session number, whether the participants were from engineering or not, the number of participants and the average response score from that focus group session. The bottom half condenses all responses into "Engineering" and "Non-Engineering", also including an average score and standard deviation of participant responses. Note that one non-engineering participant actually asked, "Can you use negative numbers?" and proceeded to rank engineering as a -1. From this participant's perspective, "not only did they [engineers] not like empathy, they openly mocked their engineer professors that exhibited any" (FG5), although this participant cautioned that this view reflected a negative personal experience that might be considered unusual.

Figure 1 shows engineering faculty believe engineering is semi-empathetic/caring at present, although this belief was highly variable with opinions ranging from "very high" (FG1) to "slightly higher than 2.5" (FG3). Non-engineering faculty, on the other hand, tend to dismiss such a notion, with the exception of Focus Group 4.

While we could present frequency counts of the coding used in this study, we opt only to include the few that are found in Appendix D, for this study is qualitative in nature. Also, as Creswell writes, "a count conveys that codes should be given equal emphasis and it disregards that the passages coded may actually represent contradictory views". (p. 152)[69] Additionally, non-engineering sessions tended to include more responses, so the total items coded are much greater. Therefore, the frequency of a code is used to discover patterns from responses, develop themes inductively from our data, and to bring to light any relevant contradictory views.

Next, we will present themes developed from the engineering focus groups and non-engineering focus groups separately. Each section will begin with a conversation around how participants defined empathy and care, followed by themes discovered from the data, and ending with a discussion on how these might be integrated into engineering teaching/curriculum. Participant responses are followed by FG# in parentheses, reflecting the focus group number from which the response was taken. Brackets are added to responses, without taking out any of the original response, in order to add clarity (e.g. if a response says "they" and means "students" we annotated by adding "they [students]").

Engineering Focus Group Results and Discussion

First, we will discuss how engineers defined/conceptualized empathy and care. Next, we will discuss four themes found from the data, (1) empathy/care are present and necessary in collegial collaboration and team exercises, (2) engineers may be perceived to be empathetic/caring towards society by providing solutions that benefit mankind, (3) empathy and care hold a presence in teacher-student interactions, and (4) while empathy and care may be present in academic and industrial pursuits, they are not openly promoted or encouraged in the fields of engineering or engineering education. Lastly, we will consider how empathy and care might be incorporated into engineering education based on the responses from our participants.

Empathy and Care as Defined by Engineers

Empathy is defined by engineering participants as "the ability to put yourself in someone else's shoes" (FG1) along with "relating to other people's feelings" (FG2), meaning that engineering

faculty suggested empathy has both an understanding and an emotive component. As one participant summarized, "You can understand a perspective at a very academic level whereas empathy for me brings in a more relational perspective as well." (FG3)

According to the participants, care(ing) is separate from empathy and involves actually doing something about a situation. As one participant stated, "Maybe empathy is a feeling, but caring is more of an active process. Maybe doing something about the situation." (FG2) Another participant further differentiated between the two, "Empathy—you might be able to assess where that person is at. Caring—whether you're prepared to take that next step and take some action to respond to that. You can have empathy without being very caring." (FG3)

Collaboration and Communication

When asked how empathy and care are present in their field, one participant responded, "I think it really comes to the importance of social interactions in the two environments [academy and industry]". Another participant suggested that the skills are important as they help "when you interact with other people, with commissions or committees…" One participant stated (in a discussion about design teams), "The team can't work if you don't understand what the other person is really thinking what drives them... So when they [students] come to me, that's what I tell them. I don't use the word caring or empathy, but that's what the word is about."(FG1) Another participant believed that the skills are good for all disciplines by stating, "I think your chances of moving ahead, in whatever field of study you are in, are going to be better if you get along well with others." (FG2)

As a whole, the first focus group reasoned that the absence of empathy is more detectable than empathy itself, as they perceived situations where conflict arises to represent a lack of empathy. As one participant questioned, "What kind of problems do you normally get in a team? One guy is trying to tell everyone else what to do… That certainly demonstrates a lack of empathy." When asked, "How do you see that they [students] demonstrate empathy and care?" a participant responded, "Absence of problems," and a second participant agreed, adding that no conflict in a situation projects more happiness, which must be contained within "an environment that probably is caring". (FG1)

Empathy and Care for Society

A participant reasoned, "You could make an argument that pretty much all of engineering is about improving society, and therefore at some level there is some elements of empathy and caring… engineering provides devices and systems that improve the quality of life of civilization."(FG1) Another participant believed many of their fellow faculty "have that sense of communal service and community and care for the planet and those sorts of things", suggesting "perhaps the sustainability emphasis provides some sort of way of thinking about caring for the environment". (FG3)

In response to a query on outsider perceptions of engineering as being empathetic and/or caring, one participant stated, "I don't know if people would explicitly think about empathy and caring, but I think it's the recognition that the technical contributions benefit their lives." (FG1) Overall,

participants played with the notion that engineers may be empathetic and/or caring in non-traditional ways, as summarized by one engineering representative:

"If you take a broader conception about what does it mean to turn empathy into a solution that provides real care in circumstances, then there are lots of examples of what engineers have done. Some not so good, some that have been absolutely foundational in terms of capacities of communities to care for people. Now the engineering realm might well be at the person-to-person end of that but it's still playing a significant role in the overall process of caring. Even down to those who work on improving crop yields and those sorts of things, so there is enough food in the world to feed people. But I guess I, when I made my assessment, was thinking more about the person-to-person engagement end of what it means to care. So it might well be that if you conceptualize caring in a different way and brought in all of that range of both personal and emotive things and capacity and capability things it would rank higher on that scale."(FG3)

Teacher-Student Interactions

Participants implied that empathy is the ability to understand their academically diverse student population, and that effective educators need this skill, as a participant stated, "It's important to understand their [students'] perspective to help them more." (FG2) Also, participants believed this understanding allows teachers to adequately assist students in need of more direct and personalized intervention, which they perceived or described as the active form of caring. As one participant stated, "The empathy there is understanding what level they [students] are at and how to bring them to a point where they can understand…" (FG1)

One participant, a faculty and engineering academic advisor, discussed the presence of empathy in a situation involving another professor and a student. The student was struggling academically due to medical issues that were beyond the student's control, and according to the participant, the empathy was present here in the professor's decision to not take the traditional path of most engineering educators who believe that "academics and life is separate and it doesn't matter what the reason is that [the student] can't get then work done". The participant continues, "The impetus was the feelings of empathy but the professor wanted to follow through with it and bringing the student to me for action was the caring part". (FG2)

The Disconnect between Empathy, Care, and Engineering

In two of the three sessions, engineering faculty participant responses tended to vacillate between minimizing and dismissing the presence of care/empathy within the practice of engineering (industry and academic) and their teaching– although not explicitly stating whether or not they personally believed it should be present or not. For example, when asked, "How much, would you say, is an emphasis, in your field of work, placed on empathy and care?" an engineering participant responded, "I suspect that my colleagues would deny any such thing." (FG1) When asked, "Why?" the respondent continued, "Oh, because, you know, most of them are guys and most of them are engineers and it's not part of the engineering culture." (FG1) In another session, a participant suggested, "I think there's a perception that… to be really successful you have to be tough as nails and maybe suppress being a nice guy."(FG2) And lastly, one participant believed having these skills are "a plus but it's not what is really necessary" to be a "good engineer" (FG2).

Still, another engineering participant reasoned that maybe the presence of empathy and/or care "depends on the personalities involved". Throughout the discussion, this participant had to revise his own reasoning. Initially, this participant suggested that empathy and care are present "at the professional level, very little. When something has to get done, something has to get done… it doesn't matter what you're going through, you'll have to perform, otherwise you're going to pay the consequences." Yet, later in the conversation this participant stated, "I think I need to modify my answer. I was thinking about a project that I've been working on, and the focus is shifted from the beginning, so it's probably less based on empathy, but initially the project manager was trying to get us motivated to succeed on the project by bringing in the potential applications and how they would… make life easier for the soldiers on the battlefield. So, I guess in terms of motivation for the project and the end result, empathy was maybe the motive for the project." (FG2)

Although some participants initially rejected the idea that empathy and care are required for the contemporary engineer, this idea was not unanimous. One participant suggested that the engineering industry embodies caring as "everybody makes a contribution" and the team environment is "very open" (FG1). Also, participants held several beliefs highlighting the fact that empathetic and caring traits exist in engineering already (primarily in the academic realm), which will be discussed in the following section.

Connecting Empathy and Care to Engineering Education

Several participants noted that incorporating empathy and/or care into engineering curriculum may be best done so indirectly. One participant reasoned, "I think for us there is a place, right, it is in a design class… the teamwork part of the design class." (FG1) Another participant suggested that the skills could be promoted "as part of a broader professionalism-type agenda… in terms of personal interactions in the workplace and things like that." (FG2) And lastly, another participant believed "that it exists in the curriculum already and different ways and it could be discussed more openly, but I don't see us having a course on it." (FG1)

However, it is important to note that some participants stated that it is not their job to teach students to be empathetic or caring. One participant believed that the skills are "very, very important" but that "we don't need a course on it" (FG1). Another participant claimed, "Our classes are adamantly, *adamantly*, technical and that's not going to change." (FG1) Ironically, that same participant later noted the importance of these skills in engineering, as the participant continues, "That's what industry expects from us… well-trained engineers who can work in a team and who can communicate and who can have empathy for their teammates and who can work well with them." (FG1)

The statements of engineers show not only a wide range of responses and different nuances; many utterances and thoughts felt as if they were formed while the conversation took place. The ad-hoc developments would indicate that a systematic explicit reflection on empathy/care in engineering is not part of the culture of academic engineering as well as that conversing about the topic was generating reality and meaning of the terms as postulated by conversation theory, our theoretical framework.

Non-Engineering Faculty Focus Group Results and Discussion

In this section, we will first discuss how the non-engineering faculty defined/conceptualized empathy and care, and secondly, how non-engineering participants tended to broadly classify and stereotype engineers. Next, we will discuss how participants thought the field of engineering could function in a more empathetic/caring manner, suggesting that in doing so there also would be more importance and value in (1) solving people's problems, (2) collegial collaboration, and (3) diversity. Lastly, we will consider how empathy and care are taught outside of engineering and how the participants believed they could be taught within engineering.

Empathy and Care as Defined by Non-Engineering Faculty

From the outset, the non-engineering faculty displayed a more mature understanding of empathy and care. This is understandable, as there are frequent mentions throughout the sessions that empathy and/or care are "a big part of" these participants' fields.

Participants frequently suggested that empathy requires relatedness with others, both on an individual or group level. As one participant claimed "the first requirement or characteristic of empathy is connectedness with other human beings." (FG6) Another participant defined empathy as the "ability to put oneself in another person's shoes and appreciate what they might be going through or contending without judgment" (FG4). Another defined it as, "Being able to understand someone else's thoughts or feelings or perspective. Maybe feeling part of that also yourself." (FG5) And additionally, "It's trying to appreciate all the viewpoints of the people you are interacting with." (FG5) Also, a few of the participants explicitly marked the distinction between sympathy and empathy. As one participant summarized, "sympathy comes from a place of power differential and feeling bad for somebody and empathy is about being on the same level, putting yourself in someone else's shoes, somebody else's perspective and really feeling that." (FG5)

Some participants differentiated between *feeling* empathy and *acting on* empathy. They believed that empathy may sometimes include an action-component, in the form of a verbal communication or something more tangible. As one participant said, "I see empathy as very strongly connected to perspective-taking and the ability to have a sense of another's experience and to then be able, if it's an act of empathy, to then be able to communicate a sense of that understanding." (FG6) Another participant suggested that empathy "can involve validating their [a patient's] point of view" simply by saying something like, "I think that's important. I'm glad you brought that up." Another instance might be through "validating the pain and reassessing the pain." (FG4) While action seemed to be a prerequisite to showing empathy, the emotional element did not seem to be required. For example, one participant explained, "I think it's possible to show empathy without necessarily feeling empathy. I mean you can learn techniques that might be appropriate for the situation that would maybe communicate empathy or a potential empathy without necessarily feeling distressed yourself or someone else's distress or something like that." (FG4).

After defining empathy, participants were asked to define care. In each session at least one participant pointed out that care has more than one definition. One participant believed there are two types, one being "caring the feeling, that you care about someone, that you want the best for

them", and a second being "caring the action." (FG5) Another participant mentioned, "There's a couple different definitions. Caring can be a physical act of doing something---I'm caring for x, y, z---but I think it's more of a personal thing in that it's more of your interests." (FG4) And another stated, "Well it [care] has an emotional component, a feeling, of wanting the well-being of another person. And then it has a behavioral component and component of supporting, of helping the people you care for, move towards their dreams." (FG6)

Some definitions of care were more succinct. For example, one participant perceived care as, "A strong affinity for someone." (FG4) Another said that "nurturing is an important word there for me in connection to caring." (FG6) Overall, both the well-wishing and the action components of care seemed highly prevalent to the discussion surrounding caring. One definition offered is "understanding others' needs and trying to help in that way" (FG5).

Participants also discussed the relationship they perceived between empathy and care. One suggestion is that "empathy is sort of a prerequisite or component" (FG6) whereas another is that empathy "really helps with caring" (FG5). Although they are not "100 percent linked" this participated stated, "I think they certainly help each other." (FG5) The participant responds, "It [caring] seems like more of an active process than empathy, although I guess there are a lot of different definitions so it's hard to say," (FG5) highlight the ambiguity surrounding the relationship between these terms.

The Stereotypes about Who Engineers Are

Uncertainty statements often accompanied the conversation surrounding the perception of engineering. Participants often admitted their beliefs were naïve and uninformed. However, focus group 5, which gave engineering an overall score of roughly 1 out of 10 in terms of being empathetic/caring, believed that their views are "spot on" with how the general public views engineering. Other comments based on stereotypical perceptions emerged during this session as well, giving the impression that these stereotypes are deeply embedded into societal images of engineering as a profession. As one participant who teaches an elementary course in STEM stated, "The first thing that I often do when I teach [a unit on engineering] is ask my students, 'so what do you think about when you think about engineering?' I get sort of two responses. One is that's hard and scary and the other is that they're not any fun at all or they're all business and those kind of perspectives." (FG5) One participant also claimed "any person on the street…ask them to define an engineer and it's someone who is numbers, and not very good with people, and kind of socially awkward and, you know, is in their little cubby hole and doing their little thing." (FG5)

There was an overarching notion that how empathetic/caring engineering already is and/or should become depends on the engineering discipline or possibly the stereotype associated with the different areas of the profession. One participant even explicitly stated that this "depends on what type of engineering." (FG4) Yet, overall, this participant believed that engineers are more "technical" than "personal". Still, this participant continued, "I think there are some engineering groups that are much more personable than others…like chemical engineering seems very dry and not personable." (FG4) Another participant, "I think people choose different kinds of engineering and it could be different for all of them." (FG6) And another adds, "I think there's a lot of variability." (FG5)

A Caring and Empathetic Engineering Discipline Focuses on Solving People's Problems

Several participants held the perception that engineers come up with technical solutions that benefit people's lives and that if this is the case, then maybe the conversation around empathy and care simply needs to be sparked. One participant believed, "Engineering is a tool that can be used to apply, to help solve people's problems—I think that's what engineering is, but you don't hear it talked about in that way very often." (FG5) It is also possible that the concept of caring in an engineering context differs from the traditional definition. As one participant stated, "We've talked about caring in a sort of one-on-one relationship of caring with a particular person, but I think there's a bigger sense of caring which is caring for a collective or a group or common fate if you like and I think engineering would benefit a lot from actually considering those aspects of things."(FG6)

It was also frequently mentioned that engineers could utilize empathy and care in their work as they attempt to appropriately meet the needs of their clients. One participant suggested that engineers "have to be able to take the perspective of a client when they are building something or designing something." (FG4) Another believed that a heightened level of empathy would help engineers, and suggested that "if they [engineers] understand somebody's perspective then they offer different solutions." (FG4)

Some participants also believed that if engineers emphasized "social responsibility" the discipline would be "vastly improve[d]" (FG6). In its current state, one participant thought that engineering problems are actually oriented in a way that they are not even required to see "the perspective of those impacted by the design" (FG4); and another participant stated, "So much of what is designed is based on purely economic sort of incentives that doesn't take into account human use and I think it's had devastating consequences for our environment, for the way people live." (FG6) Therefore, by promoting empathy, engineers might be able to better facilitate the perspective taking process.

A Caring and Empathetic Engineering Discipline Is Collaborative

Non-engineering faculty suggested that teamwork is improved when team members are more empathetic. As one participant claimed, "We get talking about where engineering might make sense in a preschool world and that it's collaborative and I think there are people who are raising voices about ideas about engineering in a more connected, people, relationship kind of way." (FG5) As another stated, "I think there must be lots of areas of their professional lives where they do have to take perspective with clients when they interact with teams and things like that." (FG6); and another added, "They have to work in groups a lot to develop to do projects…and that requires a lot of good communication and being understanding and taking the perspective of another person, so that's a part of empathy." (FG4)

Since the collaborative nature of engineering is already present, it is possible that engineering is currently promoting empathy/care. One participant stated, "I was a Chemistry major and there really wasn't empathy involved in that but the engineers were always working in teams and working on projects… I always see them seeming to have fun when I go to various things I see the engineers are doing…they all chime in and work as teams." (FG4) Another participant claimed, "I've come to define it [engineering] in a much more collaborative way, in a way that's

much more about teamwork, because there's hardly any engineering problems you solve all by yourself. You bring different specialties together, you team up." (FG5)

A Caring and Empathetic Engineering Discipline Promotes Diversity

Another suggestion was that if the engineering profession was to become more empathetic and caring, then it would directly promote diversity. For example, if engineering focused more on people-oriented issues, one participant hypothesized that gender diversity would follow, as they stated, "I think there's research to support that women often choose the kinds of engineering that have more interaction with people." (FG6) Additionally, another participant believed that engineers "are going to be working in a multicultural society, they may be working overseas…learning to develop some empathy for people who are different than you is going to be important in our global economy." (FG4)

Additionally, one participant believed that there are minority voices "afraid to speak up" in opposition to the stereotypical images of engineering. By promoting traits such as empathy and care the participant believed "you'd probably see a lot more diversity of thought" (FG5). Another participant this idea, "Diversity is a perfect word because… they're thinking a lot about how do you attract people to the field and if the field has this image that it's a negative one then there's a huge group of people—many of them may be women—and lots of other folks who would think that's not appealing." (FG5) This participant suggested that a more empathetic/caring engineering discipline will implicitly have "more gender diversity, more cultural diversity". (FG5)

Every Discipline Should Become More Empathetic/Caring

One participant expanded the conversation beyond engineering. "You don't have to be in a human services kind of field…there are not very many jobs where you aren't going to work with coworkers, supervisors, with the public, with clients… there's going to be people even in fields that don't think of themselves as people-centered fields." (FG5) Another added, "In terms of human society it [learning to be empathetic/caring] would be a very good idea. I think it should be something that all students should learn regardless of what their chosen profession is." (FG4)

Teaching Empathy and/or Care

One frequent topic of discussion was whether empathy/care could even be taught, or if they were instead innate faculties. In the interview sessions, there was some agreement that empathy and care are, to an extent, part of who you are. As one participant stated, "Some people talk about empathy as a trait—some people are just more empathetic than others." (FG4) The idea here is that people choose "helping" professions because they are able to care for others, to empathize, as part of who they are. As one participant claimed, "I think there is a fundamental trait that some people just naturally have that make them more empathetic than others. But definitely, within the nursing field, most of us gravitate towards that because we have those kinds of natural feelings—it's not something that you have to teach." (FG4)

Once the participants concluded how much of empathy and care can be attributed to a person's upbringing, then they considered whether or not it was possible to learn these characteristics.

One participant mentioned that they learned to be empathetic through "training" by "learning to listen, learning to ask, those sorts of things" (FG6). This participant continued, "There's a lot related to empathy that I think is trainable/teachable…otherwise we wouldn't be doing what we're doing," which is trying to teach these skills in more empathetic/caring careers. (FG6) Thus, the notion could be that if you learn certain skills, then learning to be empathetic or caring might follow. One participant stated, "I think it [empathy/care] can be taught though," as the participant themselves does so by teaching their patients, "you don't fix feelings, you just listen". (FG4)

The participants were able to elaborate on several strategies used in their classrooms to build these skills. One participant stated, "We specifically ask the students to think about how they use empathy as a therapeutic communication tool and identify that in conversations that they have with patients." (FG5) Another strategy involved having the students write a "reflective journal every week so that they can think about their experience and identity their own feelings in that experience, as well as doing a process recording of several conversations with patients and identify whether they were empathetic" (FG5). In nursing, one participant thought "it's ideal to have the clinical groups" (FG4); and as an example, the participant described how they emphasize the perspective taking aspect of the reflection exercise, explaining, "If I'm in clinical with them [my students], I'll tell them, 'You realize the parents have been up all night with their baby, you know, their baby has been very sick, can you imagine how that would feel? Can you imagine how much anxiety their other toddlers at home must feel?" (FG4)

Both from personal experience and as a pedagogical strategy, participants saw role modeling as a very effective method to help students become more empathetic and caring. One participant believed they had learned to be empathetic "from role-modeling from people that I trained under" (FG5) and another learned to care through their "experiences of being cared for" (FG6). Another stated the benefit of showing their students "that we have empathy by our actions" and that "having empathy for them [the students] shows them demonstration of it also" (FG4).

Apart from role modeling participants offered several other strategies to teach empathy and care explicitly in engineering education. One idea was "perspective-taking exercises" where students "come up with creative solutions" and "explore a range of solutions that took into account different perspectives or possibilities and how different stakeholders might view something" (FG6). Another idea offered was to have the students reflect on possible scenarios in engineering such as, "We have a client, and we're serving the client and we're trying to serve the client in the most efficient way, but what about what is the client going to do with this thing I create? How's it going to impact other people beyond that?" (FG6) As one participant questioned, "Do they [engineers] actually see that they're the ones that are in a car that might be in an accident and they're trapped in the back? Can they put themselves in that situation?" (FG4). Perhaps these and other exercises where engineers practice considering the consequences of unsafe and faulty designs would be in line with the previously mentioned ideas.

One participant summarized, "I have no idea what goes on in engineering classrooms for the most part, but I would think if you made objectives and some aspect of what got graded around some of what might be termed these softer skills like the ability to collaborate, their ability to correctly understand the client's problem, things like that…if that were part of the curriculum,

what was really being taught, and graded and evaluated then that would be a step in that direction." (FG5)

Closing Discussion

This study conducted an extensive literature review to determine how terms similar to empathy and care are used in engineering literature, given that the terms themselves are not often explicitly used. This allowed us to better understand the frequency and context within which these "alternative keywords" are employed in engineering literature. While the explicit use of "empathy" and "care" in engineering literature is currently limited, these keywords highlight several arenas where the discourse on empathy, care, and engineering has already begun.

Focus group interviews allowed us to investigate how faculty both inside and outside of engineering conceptualize empathy and how they perceive empathy, care, and engineering to be interrelated. There was prevailing notions that because engineers often work in teams, the team members must learn to become empathic in order to collaborate effectively. These ideas were also highlighted in the literature review where empathy skills were seen as necessary to build trust and "social capital".[44,47] Like the participants who believed that engineers may be perceived to be empathetic/caring when solving societal issues, Ermer and Vanderleest expressed the notion that engineered technology is a tool to improve lives.[71] Similarly, Vallero and Vesilind suggested that empathy would help engineers consider the impact of their designs on society.[25] This discourse *is* on engineering, empathy, and care, despite the missing explicit use of the terms "empathy" or "care".

This study adds to the body of knowledge surrounding misconceptions about the engineering profession, as many non-engineering faculty had a very limited and abstract view of what engineers do. Even after admitting this, the participants proclaimed that their naïve perceptions were most likely aligned with the general public's conceptualizations. Interestingly, even though the participants confessed they did not have a firm grip on what exactly engineers do, they felt comfortable asserting that engineers *do not* embody traits such as empathy and care. As such stereotypical images of engineering abound, we can't help but reference back to the literature review, where considering a client's needs, the importance of safety, and compassion are all terms already important parameters being considered by engineers today. In fact, if engineers today *did not* concern themselves with what it is a client needs, safety concerns, and so on then it seems unlikely that they would become successful engineers.

When engineering participants deny that empathy and care should be present in the engineering curriculum beyond the scope of team work, it seems that promoting these traits will only proceed with due diligence. Interestingly, these very participants did not take ownership of their responses, meaning they did not state that their personal view was "engineers should be 'tough as nails'" but rather posed these statements from the perspective of the engineering community as a whole. Externalizing discussion of the need for (or lack of need for) empathy and care in engineering may be a way for participants in the focus groups to give voice to what they see the dominant discourse on empathy in engineering is without explicitly stating their position on that discourse. Conversely, it could also be a way of limiting personal risk of discussing the need for empathy and care in engineering in front of colleagues. By externalizing these beliefs,

participants in the engineering focus groups are able to give voice to perspectives without taking ownership one way or the other on those perspectives.

Never did participants state that promoting empathy and care in engineering or engineering education would have negative consequences. Rather, participants only suggested potential positives of such a promotion: engineers who are empathetic are better in teams; engineers who care about the consequences of their design decisions are more valuable employees; engineers who empathize with their clients are simply better engineers than those who do not; engineering as a profession might become more gender diverse; teachers who empathize with and care about their students have a positive impact on engineering students; teachers who show that they care provide students with a more positive educational experience; the list goes on and on.

But when engineering participants state that the engineer is impersonal, manly, and not empathetic, (again, not taking ownership of these claims) they are reinforcing the stereotypes that NAE seeks to change. If the collective body of engineers wishes to reinforce these dominant images of engineering, then empathy and care will never gain value in engineering. Yet, if these fundamental traits underlie habits of mind alongside other attributes of NAE's engineer of 2020 as we propose, and if these traits are worth bringing to engineering education, as many engineering and non-engineering participants agreed, then perhaps empathy and care are the keys to exposing the positive components of engineering that deserve attention today. If by promoting empathy and care we are simply asking engineers to focus on the wellbeing of others or to consider the broader impact of their design decisions, then why has the discourse around these skills only just begun?

Limitations/Future Work

As these interview sessions were conducted with faculty, this study is lacking perspective from practicing engineers. Practicing engineers will be interviewed in the future, providing additional perspectives and insight on how important empathy and/or care are to industry and how empathy and care might be better incorporated into engineering education.

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Appendix A – Focus Group Questions

Questions for Engineering Fields

What does "empathy" mean?
- Follow-up: Describe any prerequisites to empathy.
- Follow-up: What are some of the key attributes of empathy?
- Follow-up: What has influenced your conceptualization of empathy?

What does "caring" mean?
- Follow-up: Describe any prerequisites to care and caring.
- Follow-up: What are some of the key attributes of caring?
- Follow-up: What has influenced your conceptualization of care and caring?

How much importance is placed on care and empathy…in your field? In your research? In your profession? In your teaching?

Is there value to integrate care and empathy into the curriculum?

How might empathy and caring be integrated into curriculum in your field?
- Follow-up: What problems do you see with integrating empathy and care into your curriculum?
- Follow-up: What benefits may result from integrating empathy and care into your curriculum?
- Follow-up: How could a student demonstrate acts of caring or empathy?

Where is engineering now as being an empathetic and/or caring discipline (on a scale of one to ten, with one being the least empathetic/caring discipline and ten being the most empathetic/caring discipline)?
- Follow-up: What would be the ideal rating for engineering as a caring/empathetic discipline, on a scale of one to ten?
- Follow-up: What would the engineering discipline look like at this rating?
- Do you think the perception of engineering as empathetic/caring is different from the reality? (How? Why?)

Questions for Non-Engineering Fields

What does "empathy" mean?
- Follow-up: Describe any prerequisites to empathy.
- Follow-up: What are some of the key attributes of empathy?
- Follow-up: What has influenced your conceptualization of empathy?

What does "caring" mean?
- Follow-up: Describe any prerequisites to care and caring.
- Follow-up: What are some of the key attributes of caring?
- Follow-up: What has influenced your conceptualization of care and caring?

How much importance is placed on care and empathy…in your field? In your research? In your profession? In your teaching?

Is there value to integrate care and empathy into the curriculum?

How do you teach students about empathy and care?
- Follow-up: What does that look like in your classroom?
- Follow-up: How could a student demonstrate acts of caring or empathy in your field?

Follow-up: If you were to have a colleague from a different field observe you and want to transfer your integration in their field, what tips, ideas, or strategies would you give them?

Where is engineering now as being an empathetic/caring discipline (on a scale of one to ten, with one being the least empathetic/caring discipline and ten being the most empathetic/caring discipline)?

Follow-up: What would be the ideal rating for engineering as a caring/empathetic discipline, on a scale of one to ten?

Follow-up: What would the engineering discipline look like at this rating?

Follow-up: How could an engineer demonstrate acts of caring or empathy?

Do you think the perception of engineering as empathetic/caring is different from the reality? (How? Why?)

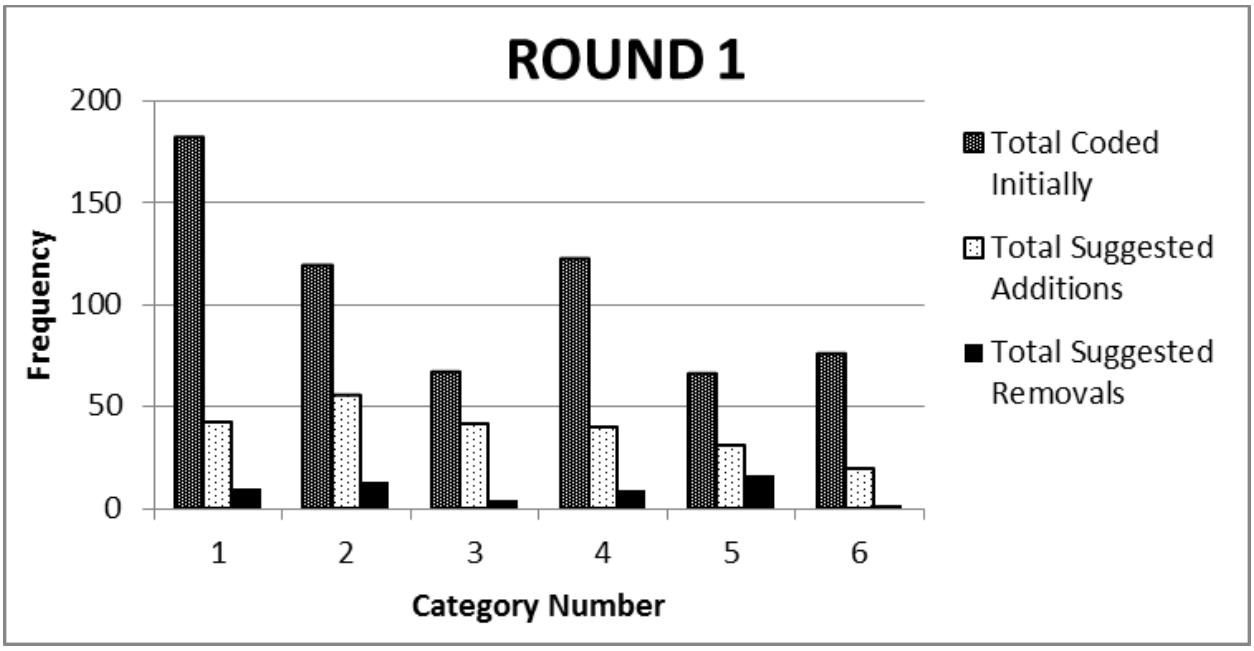
Appendix B – Coding Scheme and Frequency Counts

Group Description		Code	Eng	Non-Eng
Category 1:		**TOTALS**	**70**	**137**
Empathy and/or Care Directed Towards…	Others (two or more people)	ONDEC	33	65
	Individuals (one person)	ANDEC	18	52
	Society (groups of people, communities, etc.)	SOCEC	13	14
	Environment	ENVEC	2	2
	Self (internal)	INDEC	2	1
	Animals	ANEC	0	3
	Systems	SYSEC	1	0
	Subject/Disciplines	SUBEC	1	0
Category 2:		**TOTALS**	**33**	**123**
The Abilities that are Prerequisites to Empathy	Understanding the perspective(s) of another	UOPE	10	42
	Taking action	AE	4	10
	Relating to the feelings of another	RFE	7	5
	Listening	LPE	2	9
	Having shared experience(s)	EXPE	1	10
	Awareness of Self	ASIPE	0	10
	Absence of narcissistic tendencies	SCEP	3	7
	Appreciating other viewpoints/feelings	AOVE	1	7
	Communicating personal feelings	C=E	0	6
	Validating other's perspective	VOPVE	0	4
	Separating showing versus feeling	SvF	1	3
	Separating empathy and sympathy	EvS	0	4
	Communicating	CPE	2	2
	Awareness of personal experiences	AexpE	1	2
	Understanding non-verbal cues	SEP	1	2
	Caring	CE	2	1
Category 3:		**TOTALS**	**28**	**69**
The Abilities that are Prerequisites to Care	Taking action	AC	16	26
	Understanding the needs of another/others	UC	3	17
	Feeling connected (emotive component)	CONNC	1	7
	There exist different types of caring	DIFC	3	4
	Willingness to be held responsible	RC	0	6
	Feeling empathetic	CEPC	0	6
	Caring defined as a feeling and/or an action	FvA	2	3
	Having shared experience(s)	EXPC	3	0
	Focusing on profit	PC	1	0

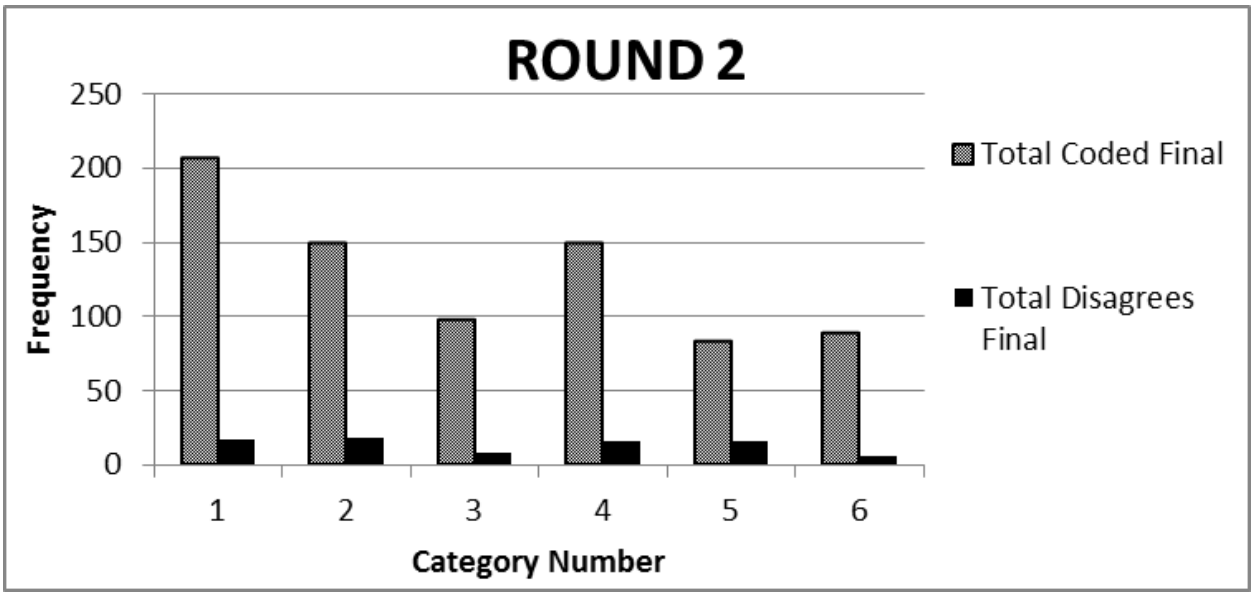
Group Description		Code	Eng	Non-Eng
Category 4:		**TOTALS**	**49**	**101**
Empathy/Care in Teaching & Learning	Teacher interactions with students	SEC	13	27
	Collaboration on a team	CTEC	14	24
	Skills that need to be taught	SNEC	2	15
	Part of one's upbringing (innate)	UPEC	3	14
	Taught through role-modeling	RMT	0	13
	Already present in engineering courses (indirectly)	PEC	8	2
	CAN be taught	SCEC	3	6
	NOT needed to be taught in engineering	NRTEC	6	0
Category 5:		**TOTALS**	**26**	**58**
Empathy/Care in Engineering	Uncertainty about what engineers do	UNC	4	16
	Not present in engineering	NE	10	8
	Present when working with client's problems	PPLEC	3	12
	Present when improving society/community	ISOCEC	6	7
	Dependent on the engineering discipline	DEP	1	10
	Related to the dominant view of engineering	DOM	2	5
Category 6:		**TOTALS**	**36**	**44**
Empathy AND Care are	A big part of participant's profession	BPOF	0	19
	Being respectful	REC	6	6
	Present in engineering industry	IEC	10	0
	Present in service-learning projects	SLEC	2	5
	Helpful in promoting diversity	DEC	0	7
	Present in absence of conflict	APTEC	6	0
	The motivation for a project	MEC	1	4
	Present in professional Ethics	EEC	2	2
	Necessary in making forward-progress	FWEC	4	0
	Components of leadership	LMEC	3	0
	Present in the academic Realm	AoI	2	1

Appendix C – Data Inter-Rater Reliability

In Figure C1, the Blue Bar represents the total items initially coded by Coder Number 1.
The Red Bar represents the total amount of suggested additions to the Code by Coder Number 2.
The green bar represents the initial total amount of suggest removals by Coder Number 2.



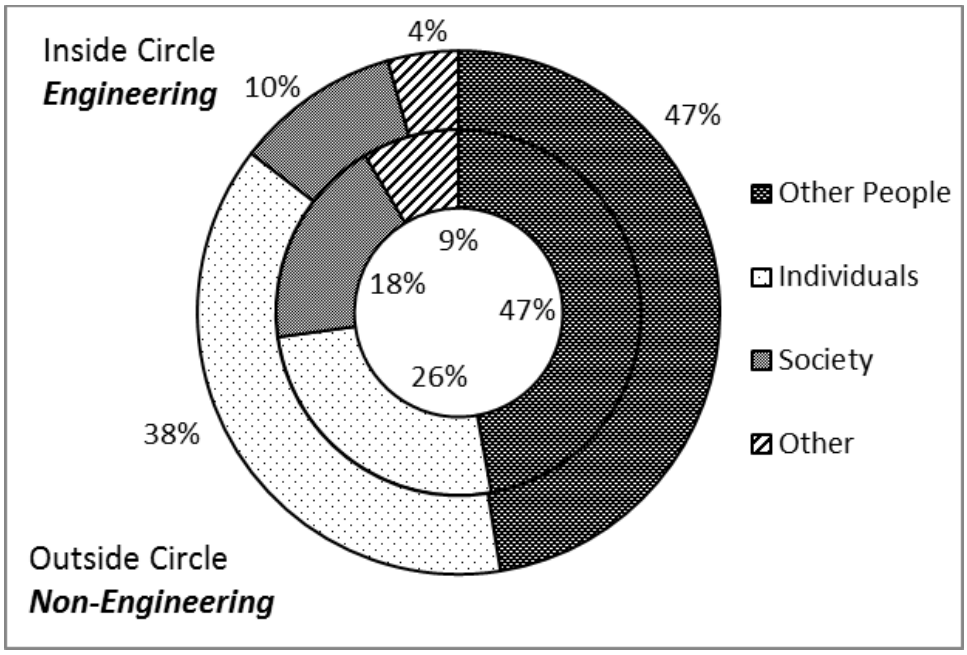
In Figure C2, the Blue Bar represents the total items coded at the end. The Red bar represents the total items for which an agreement to remove and/or recode was established by Coder 1and Coder 2.



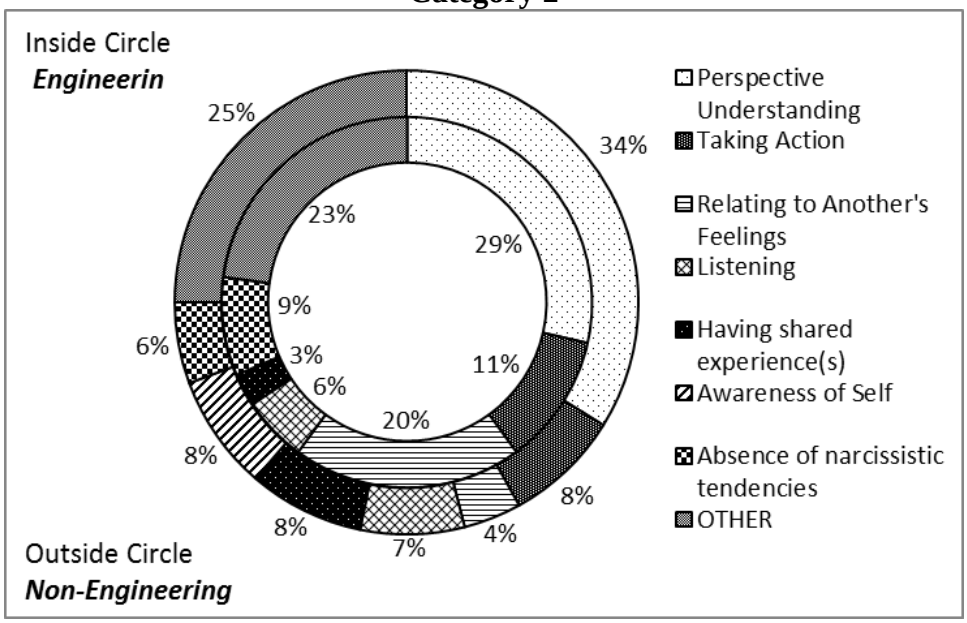
Appendix D – Percentage Comparisons

(Note: Reference Appendix B for frequency counts.)

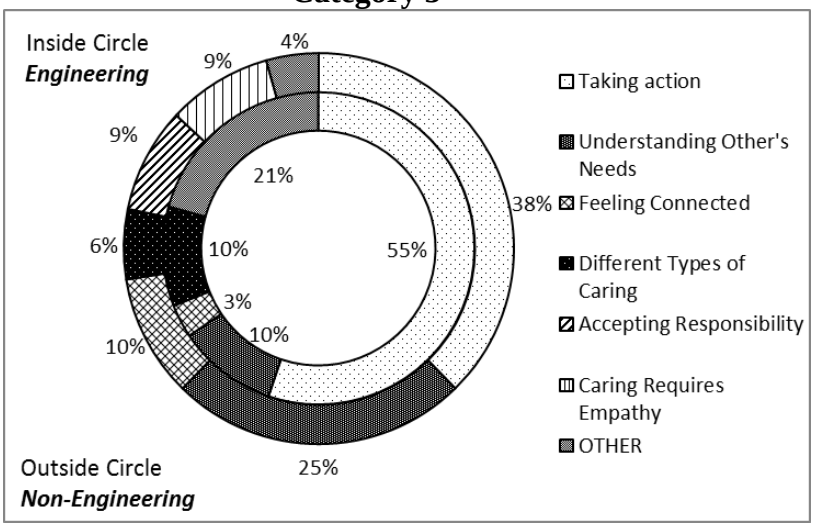
Category 1



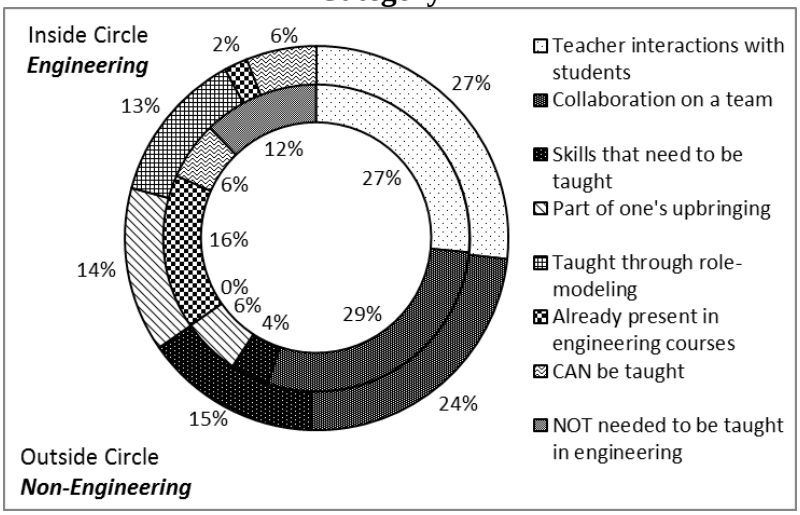
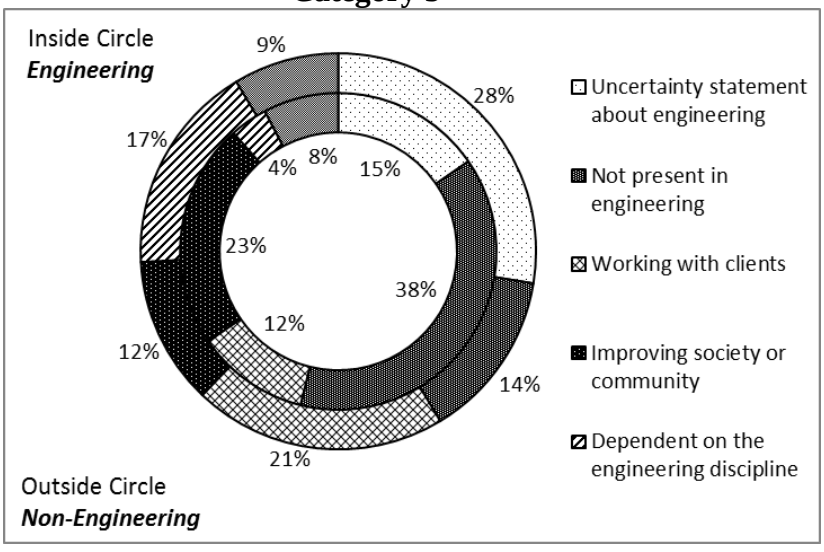
Category 2



Category 3



Category 4



Category 5