Instructor and Graduate Student Perspectives: Is Empathy a Needed Design Skill for Future Engineers?

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Abstract

Empathy has been described as a core skill for the future of engineering. Empathy is particularly important in engineering design where it has been shown to yield a deeper understanding of the problem space and users, increase ideation creativity, and improve interpersonal collaborations. However, there is limited awareness of instructor perceptions of empathy as a core engineering skill with existing work limited to two studies that explicitly included faculty. One perspective that is currently missing is that of graduate students who often have a large amount of contact with undergraduate students in their roles as teaching assistants and sessional instructors. This paper presents graduate student ($n = 36$) perceptions on empathy as a professional skill and as a pedagogical instructional area captured in a survey distributed to current graduate students (professional and research stream) within the University of Waterloo. These perceptions were compared to those of instructors (faculty and staff).

Statistical analyses were performed using a Mann Whitney U test for Likert Scale questions and Fisher's exact test for binary questions. Graduate students identified empathy as a moderately to extremely important professional skill. However, their perceived importance of teaching empathy ranged from not at all important to extremely important. This difference did not reach statistical significance ($p = 0.080$). When graduate student perceptions were compared to those of instructors, there was alignment with those of instructors ($p > 0.803$). When instructor survey results were combined with those of graduate students, empathy as a skill was perceived as significantly more important than teaching empathy ($p = 0.0314$). Graduate students older than 30 years placed greater importance on teaching empathy than their younger counterparts ($p = 0.037$). This could be due to industry experience that highlighted the importance of empathy and aligns with the perceptions of practicing engineers who identified empathy as an important intrapersonal and interpersonal skill that facilitated stronger engineering outcomes.

Future work will focus on a qualitative analysis of survey statements to better understand the broader context of graduate student perceptions and to further explore the differences between younger and older graduate students.

Introduction

Engineers are increasingly facing complex challenges in their professional context that require both technical and social competencies and include providing clean water, the ethics of developing AI, engineering better delivery of medication, and preventing nuclear terror [1]. To effectively solve these complex problems, engineers have to rigorously and adeptly apply technical skills and soft skills such as communication, collaboration, and empathy [2]. Soft skills are widely recognized as having increasing importance for employment, career success, and professional and personal satisfaction in modern engineering workplaces [3].

Empathy is a critical soft skill, focused on building emotional intelligence [2], [4], [5], [6], and has many definitions in the literature [7]. This work is working under the definition of empathy being "(1) our ability to understand another person's ideas and feelings; and (2) our inclination to feel emotionally responsive to, and act to alleviate, another person's distressful experience" [6]. This definition clearly delineates the cognitive and affective components of empathy [5], [7], [8] and embeds within its definition the concept of care or acting to improve the well-being of another [8]. Empathy is a core skill for the future of engineering [2] and has been connected to skill development in key areas related to professionalism and the practice of engineering including intra and interpersonal skills [4], [8], [9], teamwork [5], [6], [8], [9], [10], leadership [8], [9], and ethics [6], [7], [8], [11], [12]. Walther et al. [2] presented a model of empathy in the engineering context with three core dimensions of empathy as a skill, practice orientation, and "professional way of being". In professional engineering contexts empathy and other related soft skills are necessary for productive teamwork, communication to funders and investors, being professionally ethical, and generally meeting the requirements for being a licenced professional engineer [13], [14], [15].

A need to build and integrate empathy in a professional context is not unique to engineering, many professions foster and embed empathy instruction within the curriculum, such as social work [16], nursing [17], teaching [18], where processes are relatively well established at the curricular level. Other professions like physicians [19], [20], [21] and pharmacists [22], [23] were historically educated with a focus on clinical (technical) skills and have since seen substantial efforts to embed empathy instruction within the curriculum.

What does make engineering unique is that there are not yet effort to embed empathy instruction in the curriculum. This is despite the fact that empathy-based techniques and skills are explicitly integrated into some engineering design frameworks and processes including user-centered design, humanitarian engineering, human-centered design, and empathetic design [24], [25], [26], [27]. These engineering design frameworks tend to put explicit focus on perspective taking and combining this with technical, economic, and other considerations to improve the well-being of target users, society, or underserved populations [25], [26]. Even when not the explicit focus of the design process, including empathy in the design process yields a deeper understanding of the problem space and user [10], [28], increased ideation creativity [29], [30], [31] and improved interpersonal collaborations [5], [6], [7], [8], [9]. This increased creativity may be related to 'empathetic' curiosity [5], [32], [33] where greater focus is placed on making meaningful connections and links as opposed to economic considerations.

Empathy in education, when practiced by instructors towards their students, has been shown to foster a positive, inclusive learning environment that improves student outcomes, increases in-classroom and out-of-classroom communication, particularly with female students, and leads to instructors building a stronger rapport with their students [34], [35], [36]. It is important to note that applying empathetic instructional practices does not mean lowering academic standards

rather it is about supporting students and removing obstacles to learning to enable students to achieve expected academic standards within their program and profession [37].

While there are many identified benefits of integrating empathy into engineering education in terms of instructional empathetic practices and student empathy skill development as previously described, there is a lack of clarity on how those who teaching engineering students perceive empathy and as of yet this is largely focused on the undergraduate student experience. It is important to understand how educators view as empathy as Walther et al. describes the "lack of conceptual clarity" around empathy as a challenge to incorporating empathy-based pedagogy into engineering courses and curriculum, both at an undergraduate and graduate level [2]. With regards to the literature in this field outside of undergraduate education, the main study that focused on engineering faculty and practicing engineers is now a decade old [8] with emerging research on empathy in professional engineering contexts [9], [38], [39], but nothing that specifically draws out the graduate student experience.

Our earlier work in this area focused on faculty and staff [40] with this work focusing on graduate students. Graduate students hold a unique place in higher education as they are both learners and teachers. Additionally, given the intense technical focus of undergraduate engineering curriculum, graduate school may be a unique place to foster empathy in engineers. In this study, we aim to better understand graduate student perceptions of empathy and empathy-based pedagogy and determine whether their perceptions align with those of faculty and staff presented in past research [40].

Methods

An online survey was distributed to all graduate students within the Faculty of Engineering at the University of Waterloo including the School of Architecture. Given this distribution strategy, it is estimated that the survey was distributed to about 2000 individuals. Survey inclusion criteria was teaching at least one engineering or architecture course as a teaching assistant or course instructor. It is likely that a non-trivial number of survey recipients, particularly Master of Engineering (MEng) students, were ineligible to complete the survey.

This study received ethics approval from the University of Waterloo Office of Research Ethics REB 43729.

The survey was kept as consistent as possible with a similar survey distributed to faculty and staff at the same institution, presented in [40] and covered four areas: perceptions of empathy and empathy-based pedagogy, empathy-based pedagogy practice, and demographics (e.g., age, home department, professional status, etc.). A definition of empathy was provided in the survey to align thinking for the later section after respondents provided their own definition of the term. Survey responses related to empathy-based pedagogy practice are out of scope for this paper.

Within the empathy perceptions section, questions analyzed for this paper and in [40] include,

- Thinking of empathy as a professional skill, how important do you think this skill is in engineering/architecture? (1: Not at all important to 5: Extremely important)
- Describe what, if any, value you see in empathy as an engineering/architecture skill.

Within the empathy-based pedagogy perceptions section, questions analyzed for this paper and in [40] include,

- How important do you think it is to teach empathy in an engineering/architecture undergraduate program? (1: Not at all important to 5: Extremely important)
- What advantages do you see to including empathy instruction in engineering or architecture courses?
- What challenges do you see to including empathy instruction in engineering or architecture courses?
- Do you think empathy instruction can support the development of graduate attributes in engineering students? Select all that apply. (Options: Knowledge Base, Problem Analysis, Investigation, Design, Use of Engineering Tools, Individual and Teamwork, Communication Skills, Professionalism, Impact of Engineering, Ethics and Equity, Economics and Project Management, Lifelong Learning)

Survey results when presented numerically are presented as median, interquartile range (IQR) with 'Not at all Important' assigned a value of 1, progressing in increments of 1, to 'Extremely Important' assigned a value of 5. Mann-Whitney U test was used for Likert Scale questions and Fisher's exact test for binary questions with $\alpha = 0.05$. Unless otherwise stated, statistical analyses were performed as two-tailed tests. Analyzed sub-groups include self-identified gender, age, and student type. Due to the limited sample size, two sub-groups related to age were used with 30 years used as a cut-off point to identify younger and older survey respondents. For self-identified gender and student type, non-binary and MEng were excluded from the sub-group analyses given that there was only one survey respondent in these categories. All statistical tests were performed in R version 4.1.2.

Performing a thematic analysis of open-ended survey questions is outside the scope of work for this paper, however, some quotations are provided for context. Quotations will be identified based on the degree (e.g., PhD, MASc, MEng) and home department of the survey respondent.

The data from the graduate student survey will be analyzed separately and alongside data from a faculty and staff survey (n = 35) [40]. Analyzed survey questions were the same between the two surveys and additional information on faculty and staff survey respondents can be found in [40].

Survey Respondents

Forty-five graduate students started the survey, with nine removing themselves or not completing any of the empathy-focused survey questions. Thirty-six individuals who answered at least one empathy-focused survey question and met the inclusion criteria were included for analysis. The

number of respondents for each individual question vary as some individual chose to answer only a subset of the questions.

Of the 36 survey respondents, identified home departments include: architecture (n = 1), chemical engineering (n = 7), civil and environmental engineering (n = 2), management sciences (n = 3), mechanical and mechatronics engineering (n = 6), and systems design engineering (n = 17). Fifteen survey respondents were PhD students, 20 were MASc students, and one was an MEng student. Two of the respondents self-identified as a Professional Engineer (P.Eng.). Twenty-five survey respondents identified as male, ten identified as female, and one identified with a non-binary gender identity. This non-binary gender identity is not provided due to the potentially identifiable nature of this information. The age of survey respondents was 27.9 ± 8.3 years (range: 23 to 66 years).

Results

Graduate students perceived empathy as an important professional skill (4, IQR: 4 to 4.5) with 'very important' being the most frequent response (n = 22) and no respondents identifying an importance less than moderate (see Figure 1). There were no differences in the perceived importance of empathy as a professional skill between male and female identifying graduate students (p = 0.704), PhD and MASc students (p = 0.379), or age groups (p = 0.174). These results are inline with those of faculty and staff (p = 0.803) who also had a most frequent response of 'very important' and no respondents identifying an importance less than moderate [40].

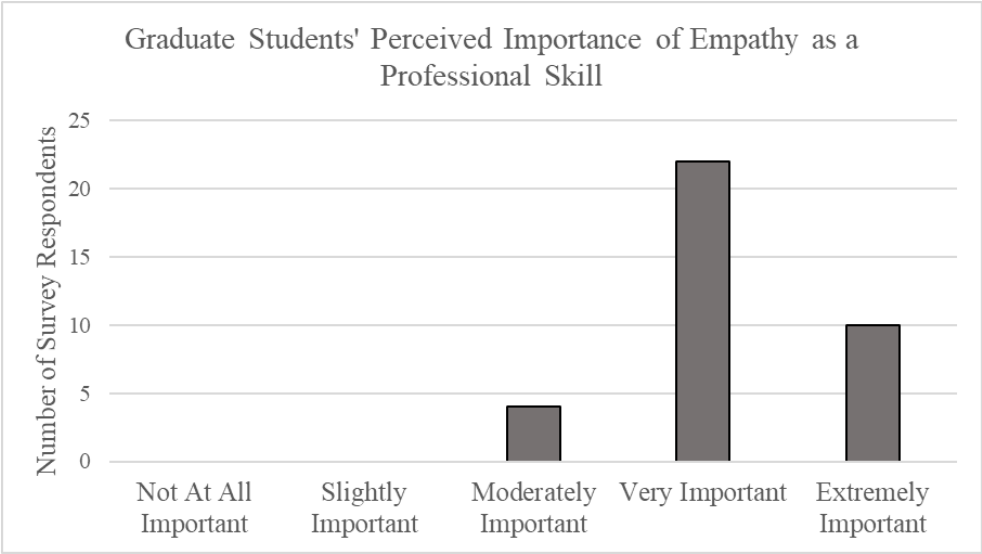

Figure 1. Graduate students' identified importance of empathy as a professional skill.

Individuals expressed a wide range of opinions related to their identification of empathy as an important professional skill with some identifying it as a general, not engineering specific skill: "*It's not an engineering skill but it is a useful skill for engineers*." (PhD, Chemical Engineering)

Others connected empathy to communication:
"*I think empathy is important in a vocation. In engineering you'll be working for clients, with coworkers, and for employers. From a life skill perspective to interact with anyone, empathy is an extremely important skill to have to be able to communicate effectively with other people*." (MASc, Mechanical and Mechatroncis Engineering)

There were some respondents who directly connected empathy to engineering design and understanding the impact of engineering work:
"*Certain systems we create can be harmful to people in society, or require certain usability considerations for subsets of the population such as disabled persons. It is important to consider those impacts which requires the ability to empathize with the perspectives of these groups."* (MASc, Mechanical and Mechatroncis Engineering)

"*When designing or improving systems, it is important to have empathy for the users of the system so that we can create more useful and usable tools and environments for them*." (PhD, Systems Design Engineering)

Finally, some identified empathy as being particularly relevant for mentorship:
"*Its value is most important when mentoring junior engineers."* (MASc, Systems Design Engineering)

When asked their perceived importance of teaching empathy, graduate students expressed a wider range of opinions with a median of 4 – very important (IQR: 3 to 4). The most frequent response was still 'very important' (n = 17), but three individuals identified teaching empathy as either sightly important or not at all important (see Figure 2). This was different from the perceived importance of empathy as a professional skill where the lowest selected importance was 'moderately important'. However, this difference did not reach statistical significance ($p = 0.080$). This result is again inline with those of faculty and staff ($p = 0.976$) with seven respondents identifying teaching empathy as slight important or not at all important even though 'very important' was the most frequent response (n = 12) [40].

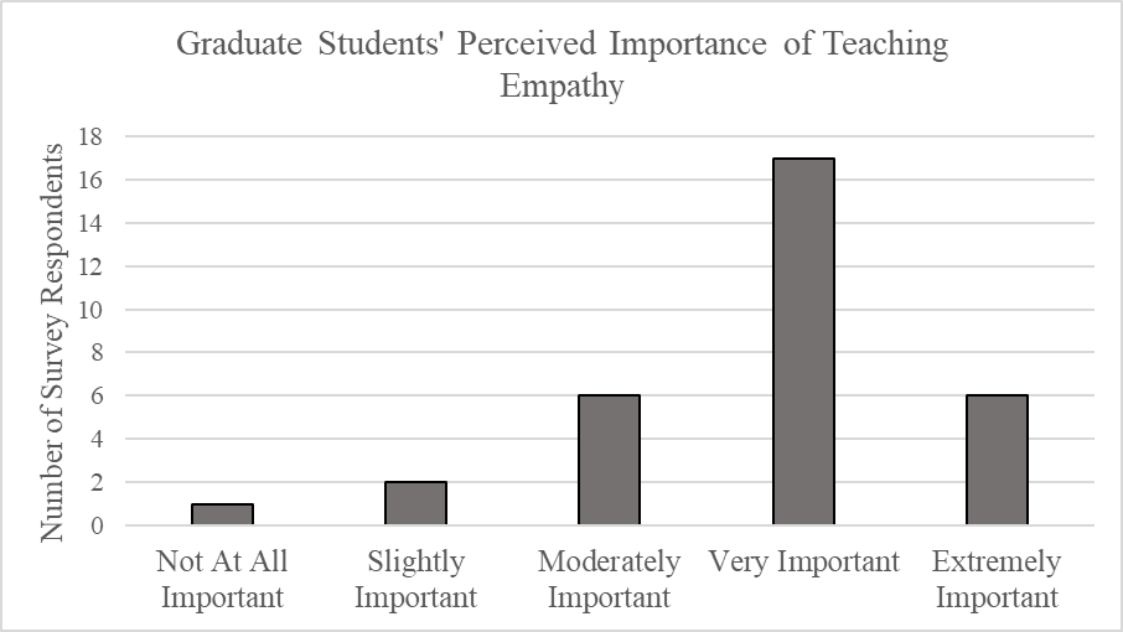

Figure 2. Graduate students' identified importance of teaching empathy.

This wider range of opinions on the importance of teaching empathy was reflected in survey responses where some saw empathy as not important to prioritize in engineering education:
"*This is an important skill, but not something that needs to be taught in engineering courses. time is much better spent in other places*." (MASc, Mechanical and Mechatronics Engineering)

While others connected it to improved learning environments and collaboration:
"*We can understand students better*." (MASc, Mechanical and Mechatronics Engineering)

"*Bringing the best of each student, and a more effective group of engineers who can cooperate better with each other*." (MASc, Systems Design Engineering)

Several respondents connected teaching empathy to strengthening design skills and user-centered approaches:
"*Encourages engineers to be more receptive and understanding of users and stakeholders in the design process*." (MASc, Systems Design Engineering)

"*Empathy is part of the design process and should be taught to undergrad students*." (PhD, Systems Design Engineering)

Older (≥ 30 years) graduate students placed significantly more importance on teaching empathy than their younger peers ($p = 0.0366$). Of the five older respondents, two identified teaching as 'very important' and three identified teaching as 'extremely important'. No differences in perceived importance of teaching were identified between male and female identifying graduate students ($p = 0.697$) or PhD and MASc students ($p = 0.764$).

Given that there was no statistical difference in survey results related to empathy as a professional skills and teaching empathy when comparing graduate responses to those of faculty and staff, survey results were combined to examine for statistical significance. The higher perceived importance placed on empathy as a professional skill (4, IQR: 4 to 5) compared to teaching empathy (4, IQR: 3 to 4) approached statistical significance with a two-tailed analysis ($p = 0.0629$) and achieved statistical significance with a one-tailed analysis ($p = 0.0314$).

Graduate students were also asked to identify any graduate attributes that would be supported by empathy instruction with the percent selection across all attributes shown in Figure 3. The most frequently selected attribute was 'Communication Skills' with 93.3% and the least frequently selected attribute was 'Use of Engineering Tools' with 17.0%. The median number of graduate attributes selected was 7 (IQR: 5.25 to 8.75). One survey respondent selected all the graduate attributes as being supported by empathy instruction. There were no differences in the number of graduate attributes selected between male and female identifying graduate students ($p = 0.126$), PhD and MASc students ($p = 0.263$), or age groups ($p = 0.632$). Graduate students' selections were compared to those of faculty and staff and no significant differences were identified ($p \geq 0.106$). Data for this comparison is available upon request.

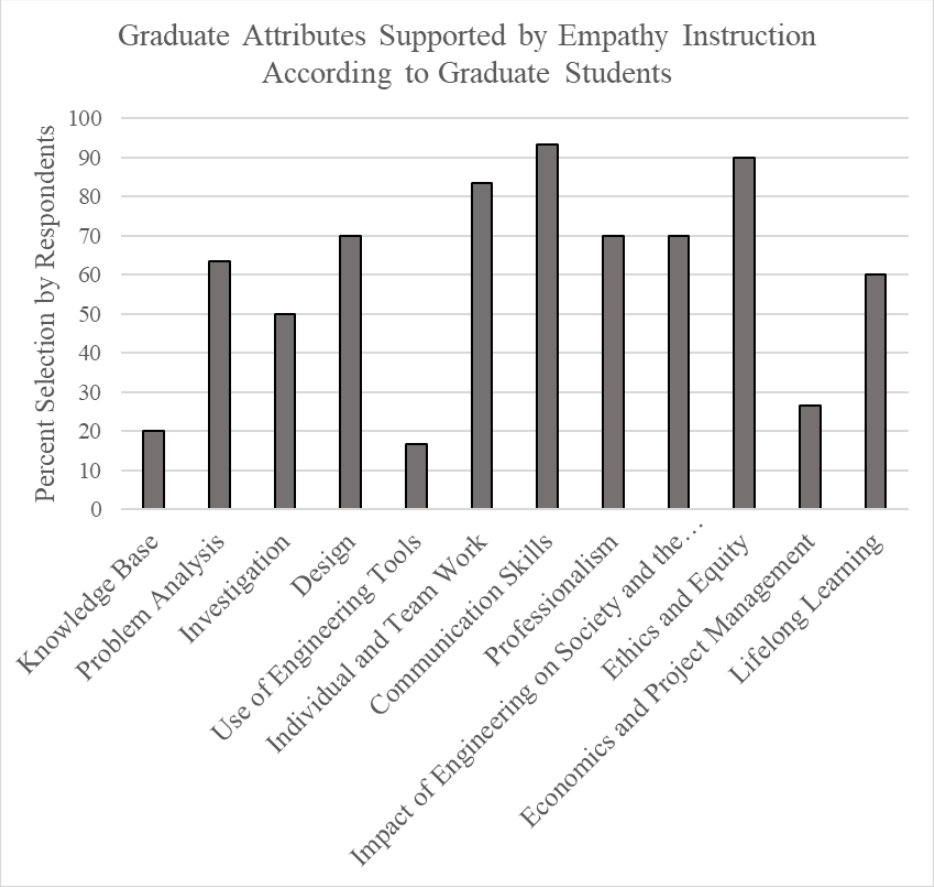

Figure 3. Graduate attributes selected by graduate students as being supported by empathy instruction.

Discussion

Graduate students identified empathy as a moderately to extremely important professional skill with 'very important' being the most frequent selection. This perception of empathy as a professional skill aligns with those of faculty and staff at the same institution [40]. As shown in the provided quotes, empathy skills were identified as a broader skill that is not specific to engineering in addition to being connected to communication, mentorship, and design. The connections to communication, mentorship in the context of leadership, and design have all been identified as benefits of empathetic skill development in the literature [4], [5], [7], [8], [9], [41].

Graduate students expressed a wider range of opinions related to the importance of teaching empathy, ranging from not at all important to extremely important. It is important to note that the most frequent response was 'very important', which did align with perceptions of empathy as a professional skill. This wider range of opinions related to teaching empathy again aligns with those of faculty and staff at the same institution [40]. Interestingly, when examined in isolation, this difference in perceptions of empathy as a professional skill versus something that should be taught did not reach statistical significance when graduate student responses were analyzed in isolation ($p = 0.080$). However, when combined with results of an earlier survey distributed to faculty and staff, the difference did reach statistical significance with a one-tailed statistical test ($p = 0.0314$). An important area of future work is to expand this survey beyond one institution to determine whether this difference is institutional specific or exists more broadly within the engineering academic community.

In alignment with the broader opinions on the importance of teaching empathy, the provided quotes also reflect a range of opinions. Some graduate students identified empathy as not important for engineering education or connected empathy to improving the learning environment and student relationships. This suggests a perception that empathy can help engineering instructors to better support their students but is not something that students need to receive instruction on. Indeed, studies have found that instructional empathy does support a positive, inclusive learning environment while keeping academic standards consistent [37], [42]. Other graduate students identified teaching empathy as being an important part of design instruction. This aligns with several user-centered design processes and human factors design techniques that explicitly or implicitly require empathy skills to implement [6], [43], [44], [45].

Older graduate students, defined as 30 years of age or older, placed significantly higher importance on teaching empathy than their younger counterparts ($p = 0.0366$). Older graduate students exclusively identified empathy as a very or extremely important professional skill and as very or extremely important to teach. This means that they showed greater consistency in their opinions across these two dimensions in contrast to their younger peers. This aligns with perceptions of practicing engineers who also identified the value of empathy in the workplace [9]. This provides early evidence to suggest that working in industry or greater life experience has an impact on engineers' perceptions of empathy. More specifically, they place greater importance on teaching empathy. It is important to note that the sample of older survey

respondents was limited with only five respondents meeting the 30 years old criteria. It will be important to explore this finding with a larger sample size to determine whether it persist. A larger sample size may also allow for a more sophisticated analysis of age beyond the current binary approach. Focus groups or interviews with older graduate students could also yield greater depths of insight into this finding and is an important area of future work.

Graduate attributes identified as being supported by empathy-based pedagogy were attributes that generally align with soft skill development. The most frequently selected attributes were 'Communication Skills' (93%), 'Ethics and Equity' (90%), and 'Individual and Teamwork' (83%). The least frequently selected attributes were 'Use of Engineering Tools' (17%) and 'Knowledge Base' (20%). These findings align with those of the earlier faculty and staff survey [40] and literature connecting empathy to soft skills [2].

This study does have several limitations, some of which have already been identified. This study was limited to one institution and a relatively small number of respondents for quantitative analysis, particularly when analyzing subgroups. There are risks associated with small sample size, including nonresponse bias [46]. A larger multi-institutional study is an important area of future work to determine whether these findings expand beyond one institution or whether there are institutional differences in empathy perceptions. A larger study would also yield a larger sample size allowing for more robust statistical analyses.

This paper also reports solely on quantitative analyses of survey responses even though it is part of a larger mixed methods study. Future work will include a qualitative thematic analysis of statements from the study. Another important area of future work is expanding on initial findings that older graduate students have differing perceptions of the importance of teaching empathy. This could involve in-depth conversations with older graduate students and expanding this research to include engineering practitioners to examine the possible impact of working in industry on shaping and influencing perceptions on the importance of empathy in engineering both at work and in education. While engineering practitioners have been interviewed by Hess et al., this work was published eight years ago and several critical world events, including the COVID-19 pandemic [47], have occurred and may have had a significant impact on work culture, work practices, and the relative importance of different skills in engineering work environments.

Conclusion

Graduate students value empathy as a professional skill but have a range of opinions on the importance of teaching empathy. Older graduate students place more importance on teaching empathy than their younger counterparts. However, gender and degree type did not significantly influence perceptions related to empathy. There appears to be consistency in empathy perceptions between graduate students and faculty and staff. Future work includes expanding the exploration of empathy perceptions to multiple institutions to broaden insights into more diverse locations. Qualitative analyses of survey statements are planned and will yield a better

understanding of the broader context of graduate students' perceptions of empathy. There is significant potential with future work including better insights into how and where to include empathy in graduate engineering education, and whether embedding empathy in graduate engineering education would also lead to impacts on undergraduate students given graduate students' unique role as both learners and teachers.

References

[1] "Grand Challenges - 14 Grand Challenges for Engineering." Accessed: Jan. 30, 2024. [Online]. Available: https://www.engineeringchallenges.org/challenges.aspx

[2] J. Walther, S. E. Miller, and N. W. Sochacka, "A Model of Empathy in Engineering as a Core Skill, Practice Orientation, and Professional Way of Being," *Journal of Engineering Education*, vol. 106, no. 1, pp. 123–148, 2017, doi: https://doi.org/10.1002/jee.20159.

[3] B. Penzenstadler, G. Haller, T. Schlosser, and G. Frenzel, "Soft Skills REquired: A Practical Approach for Empowering Soft Skills in the Engineering World," in *2009 Collaboration and Intercultural Issues on Requirements: Communication, Understanding and Softskills*, Aug. 2009, pp. 31–36. doi: 10.1109/CIRCUS.2009.5.

[4] C. Rasoal, H. Danielsson, and T. Jungert, "Empathy among students in engineering programmes," *European Journal of Engineering Education*, vol. 37, no. 5, pp. 427–435, Oct. 2012, doi: 10.1080/03043797.2012.708720.

[5] M. Alsager Alzayed, C. McComb, J. Menold, J. Huff, and S. R. Miller, "Are you feeling me? An exploration of empathy development in engineering design education," *Journal of Mechanical Design*, pp. 1–57, Oct. 2020, doi: 10.1115/1.4048624.

[6] X. Tang, "From 'Empathic Design' to 'Empathic Engineering': Toward a Genealogy of Empathy in Engineering Education," presented at the 2018 ASEE Annual Conference & Exposition, Salt Lake City, Utah, 2018, p. 22414.

[7] J. L. Hess and N. D. Fila, "The Development and Growth of Empathy Among Engineering Students," in *ASEE*, New Orleans, Los Angeles: American Society for Engineering Education, 2016, p. 16281. Accessed: Feb. 18, 2021. [Online]. Available: https://scholarworks.iupui.edu/handle/1805/12192

[8] J. Strobel, J. Hess, R. Pan, and C. A. W. Morris, "Empathy and care within engineering: qualitative perspectives from engineering faculty and practicing engineers," *Engineering Studies*, vol. 5, no. 2, pp. 137–159, Aug. 2013, doi: 10.1080/19378629.2013.814136.

[9] J. L. Hess, J. Strobel, and R. Pan, "Voices from the workplace: practitioners' perspectives on the role of empathy and care within engineering: Engineering Studies: Vol 8, No 3," *Engineering Studies*, vol. 8, no. 3, pp. 212–242, 2016.

[10] G. Hoople and A. Choi-Fitzpatrick, "Engineering Empathy: A Multidisciplinary Approach Combining Engineering, Peace Studies, and Drones," presented at the 2017 ASEE Annual Conference & Exposition, Columbus, Ohio, 2017, p. 19372.

[11] J. L. Hess, S. Miller, S. Higbee, G. A. Fore, and J. Wallace, "Empathy and ethical becoming in biomedical engineering education: a mixed methods study of an animal tissue harvesting laboratory," *Australasian Journal of Engineering Education*, vol. 0, no. 0, pp. 1–11, Jul. 2020, doi: 10.1080/22054952.2020.1796045.

[12] J. Howcroft, K. Mercer, and J. Boger, "Developing ethical engineers with empathy," presented at the CEEA 2021, Jun. 2021.

[13] "Overview of the Licensing Process | Engineers Canada." Accessed: Jan. 30, 2024. [Online]. Available: https://engineerscanada.ca/become-an-engineer/overview-of-licensing-process
[14] National Society of Professional Engineers, "Code of Ethics | National Society of Professional Engineers." Accessed: Feb. 18, 2021. [Online]. Available: https://www.nspe.org/resources/ethics/code-ethics
[15] Engineers Canada, "Public Guideline on the code of ethics | Engineers Canada." Accessed: Feb. 18, 2021. [Online]. Available: https://engineerscanada.ca/publications/public-guideline-on-the-code-of-ethics
[16] K. E. Gerdes and E. A. Segal, "A Social Work Model of Empathy," *Advances in Social Work*, vol. 10, no. 2, Art. no. 2, Dec. 2009, doi: 10.18060/235.
[17] T. Levett-Jones, R. Cant, and S. Lapkin, "A systematic review of the effectiveness of empathy education for undergraduate nursing students," *Nurse Education Today*, vol. 75, pp. 80–94, Apr. 2019, doi: 10.1016/j.nedt.2019.01.006.
[18] K. McGowan, L. A. Christenson, and L. Muccio, "Collaborative Professional Learning: An Exploration of Empathy in Early Childhood Teacher Education," *Journal of Research in Childhood Education*, vol. 35, no. 1, pp. 111–121, Jan. 2021, doi: 10.1080/02568543.2020.1801537.
[19] N. Díez-Goñi and M. C. Rodríguez-Díez, "Why teaching empathy is important for the medical degree," *Revista Clínica Española (English Edition)*, vol. 217, no. 6, pp. 332–335, Aug. 2017, doi: 10.1016/j.rceng.2017.03.002.
[20] S. A. Batt-Rawden, M. S. Chisolm, B. Anton, and T. E. Flickinger, "Teaching Empathy to Medical Students: An Updated, Systematic Review," *Academic Medicine*, vol. 88, no. 8, p. 1171, Aug. 2013, doi: 10.1097/ACM.0b013e318299f3e3.
[21] Y. C. Zhou *et al.*, "A systematic scoping review of approaches to teaching and assessing empathy in medicine," *BMC Medical Education*, vol. 21, no. 1, p. 292, May 2021, doi: 10.1186/s12909-021-02697-6.
[22] M. L. Manolakis, J. L. Olin, P. L. Thornton, C. R. Dolder, and C. Hanrahan, "A Module on Death and Dying to Develop Empathy in Student Pharmacists," *American Journal of Pharmaceutical Education*, vol. 75, no. 4, p. 71, May 2011, doi: 10.5688/ajpe75471.
[23] A. M. H. Chen, M. E. Kiersma, K. S. Yehle, and K. S. Plake, "Impact of an Aging Simulation Game on Pharmacy Students' Empathy for Older Adults," *American Journal of Pharmaceutical Education*, vol. 79, no. 5, p. 65, Jun. 2015, doi: 10.5688/ajpe79565.
[24] J. A. Leydens and J. C. Lucena, "The Problem of Knowledge in Incorporating Humanitarian Ethics in Engineering Education: Barriers and Opportunities," in *Proceedings. Frontiers in Education. 36th Annual Conference*, Oct. 2006, pp. 24–29. doi: 10.1109/FIE.2006.322645.
[25] M. G. Burnham, "The 'systems approach' to human problems: How humanitarian engineering can help," in *2009 IEEE International Symposium on Technology and Society*, May 2009, pp. 1–10. doi: 10.1109/ISTAS.2009.5155899.
[26] D. Nieusma and D. Riley, "Designs on development: engineering, globalization, and social justice," *Engineering Studies*, vol. 2, no. 1, pp. 29–59, Apr. 2010, doi: 10.1080/19378621003604748.
[27] C. Titus, C. B. Zoltowski, and W. C. Oakes, "Designing in a Social Context: Situating Design in a Human-Centered, Social World," presented at the 2011 ASEE Annual

Conference & Exposition, Vancouver, BC, Jun. 2011, p. 22.444.1-22.444.11. doi: 10.18260/1-2--17725.
[28] K. Battarbee and I. Koskinen, “Co-experience: user experience as interaction,” *International Journal of CoCreation in Design and Arts*, vol. 1, no. 1, pp. 5–18, 2005.
[29] D. G. Johnson, N. Genco, M. N. Saunders, P. Williams, C. C. Seepersad, and K. Hölttä-Otto, “An Experimental Investigation of the Effectiveness of Empathic Experience Design for Innovative Concept Generation,” *Journal of Mechanical Design*, vol. 136, no. 5, pp. 052009, 12 pages, Mar. 2014, doi: 10.1115/1.4026951.
[30] N. Genco, D. Johnson, K. Ho¨ltta¨-Otto, and C. C. Seepersad, “A Study of the Effectiveness of Empathic Experience Design as a Creativity Technique,” presented at the ASME 2011 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, American Society of Mechanical Engineers Digital Collection, Jun. 2012, pp. 131–139. doi: 10.1115/DETC2011-48256.
[31] S. Raviselvam, K. Hölttä-Otto, and K. L. Wood, “User Extreme Conditions to Enhance Designer Empathy and Creativity: Applications Using Visual Impairment,” presented at the ASME 2016 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, American Society of Mechanical Engineers Digital Collection, Dec. 2016. doi: 10.1115/DETC2016-59602.
[32] M. Buheji, *Designing a Curious Life*. AuthorHouse, 2019.
[33] R. Phillips, “Curious about Others: Relational and Empathetic Curiosity for Diverse Societies,” *New Formations*, vol. 88, no. 88, pp. 123–142, Mar. 2016, doi: 10.3898/NEWF.88.02.2016.
[34] M. K. Nadler and L. B. Nadler, “The Roles of Sex, Empathy, and Credibility in Out-of-Class Communication Between Faculty and Students,” *Women’s Studies in Communication*, vol. 24, no. 2, pp. 241–261, Oct. 2001, doi: 10.1080/07491409.2001.10162436.
[35] A. M. Wright and K. R. Meyer, “Exploring the Relationship Between Students with Accommodations and Instructor Self-Efficacy in Complying with Accommodations,” *Higher Learning Research Communications*, vol. 7, no. 1, Nov. 2011, doi: 10.18870/hlrc.v7i1.367.
[36] C. O. Araya and J. Martin, “What is teacher empathy in engineering education? A review of the literature,” presented at the 2022 ASEE Annual Conference & Exposition, Aug. 2022. Accessed: Jan. 23, 2024. [Online]. Available: https://peer.asee.org/what-is-teacher-empathy-in-engineering-education-a-review-of-the-literature
[37] S. Meyers, K. Rowell, M. Wells, and B. C. Smith, “Teacher Empathy: A Model of Empathy for Teaching for Student Success,” *College Teaching*, vol. 67, no. 3, pp. 160–168, Jul. 2019, doi: 10.1080/87567555.2019.1579699.
[38] J. L. Hess, J. Strobel, R. (Celia) Pan, and C. A. Wachter Morris, “Insights from industry: a quantitative analysis of engineers’ perceptions of empathy and care within their practice,” *European Journal of Engineering Education*, vol. 42, no. 6, pp. 1128–1153, Nov. 2017, doi: 10.1080/03043797.2016.1267717.
[39] M. Marinelli, S. Male, E. Chapman, and J. Strobel, “Engineers’ perceptions of the importance of empathy and care: initial insights from engineers practicing in Australia,” presented at the Towards a new future in engineering education, new scenarios that european alliances of tech universities open up, Universitat Politècnica de Catalunya, Sep. 2022, pp. 2066–2071. doi: 10.5821/conference-9788412322262.1386.

[40] J. Howcroft and K. Mercer, “Where We Are: Understanding Instructor Perceptions of Empathy in Engineering Education,” *Proceedings of the Canadian Engineering Education Association (CEEA)*, Nov. 2022, doi: 10.24908/pceea.vi.15913.
[41] J. L. Fertig and S. Kumpaty, “Empathy as Key to Inclusivity in Engineering Education,” in *Proceedings 2022 ASEE Conference*, Minneapolis, Minnesota, Jun. 2022, p. 38050.
[42] J. Ross, K. Hicks-Roof, M. Cosby, and A. Arikawa, “Instructor and Student Perceptions of Teacher Empathy in Higher Education,” *College Teaching*, vol. 71, no. 1, pp. 28–37, Jan. 2023, doi: 10.1080/87567555.2022.2049673.
[43] M. Lewrick, P. Link, and L. Leifer, *The Design Thinking Toolbox: A Guide to Mastering the Most Popular and Valuable Innovation Methods*, 1st edition. Hoboken, New Jersey: Wiley, 2020.
[44] B. Martin and B. Hanington, *Universal Methods of Design*, First. Rockport Publishers, 2012.
[45] J. D. Lee, C. D. Wickens, Y. Liu, and L. N. Boyle, *Designing for People: An Introduction to Human Factors Engineering*, 3rd edition. Charleston, SC: CreateSpace Independent Publishing Platform, 2017.
[46] J. E. Fincham, “Response Rates and Responsiveness for Surveys, Standards, and the Journal,” *AJPE*, vol. 72, no. 2, Sep. 2008, doi: 10.5688/aj720243.
[47] D. Cucinotta and M. Vanelli, “WHO Declares COVID-19 a Pandemic,” *Acta Biomed*, vol. 91, no. 1, pp. 157–160, Mar. 2020, doi: 10.23750/abm.v91i1.9397.