Board 203: A Research Study on Assessing Empathic Formation in Engineering Design

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A Research Study on Assessing Empathic Formation in Engineering Design

Abstract

Design is a prominent aspect of engineering education and developing empathy in engineering graduates through design is becoming an essential part of engineering education. However, we need a robust way to measure empathic development in engineering. The primary objective of this study is to provide the engineering design community with a contextually valid instrument for measuring empathy in undergraduate engineering design contexts. We aim to address three primary objectives: (1) To expand and modify a pilot instrument for assessing empathy in engineering design via co-creation with a diverse group of engineering design instructors and student interviews; (2) To test and validate an instrument for assessing empathic formation in engineering design via a multi-methods research design which includes formative feedback from design educators, a pilot student sample, and a large student sample that includes multiple university sites and disciplines; and (3) To identify changes in empathy types across engineering design when applying the instrument in multiple disciplinary design contexts and by accounting for how instructional design contexts and practices influence empathic formation. At the time of this writing, this project is concluding Year 1, but emergent findings have supported the need for a contextually valid assessment in engineering design. Moreover, this project has begun fostering community among a small group of design instructors. Upon completion of this work, this project will generate an instructional tool for assessing empathy in engineering design, new knowledge on best practices for promoting empathic formation in engineering design, and community among design instructors who are interested in empathy in engineering design.

Keywords: Empathy; Engineering Design; Empathic Design; Co-Creation

Introduction

In this NSF work, we build on the premise that "without the understanding of what others see, feel, and experience, design is a pointless task" [1]. To better understand others' perceptions, feelings, and experiences, designers need empathy. Roughly a decade ago, few studies explicitly focused on empathy in engineering [2], but empathy is becoming a core focus in engineering education scholarship [3-11], especially in the context of engineering design [12-14]. This study aims to build on this burgeoning line of research.

Despite the growth in interest, there is no contextually valid approach for measuring empathy in engineering design. As a result, there is no robust way to accurately identify the impacts of engineering design instruction on empathic formation. While numerous measures of empathy exist [6, 9, 15-19], these instruments tend to conceptualize empathy as a general trait or tendency. However, within disciplinary contexts, empathy manifests in unique ways when compared to general life experiences [9]. Thus, discipline-specific assessment measures of empathy have been created in several fields which account for empathy's manifestation in professions outside of engineering, such as social work [18] and medicine [19]. However, such measures do not exist – or at least have not yet been fully vetted – in engineering or engineering design [20].

We need a robust way to measure the development of empathy in engineering contexts, including (but not limited to) empathy in engineering design. This work brings together two related bodies of literature on engineering design and empathy. We previously leveraged frameworks from these areas to develop and test a pilot instrument that accounts for how empathy manifests across three design phases [20, 21]. We seek to iterate on this measure to design more robust and broadly applicable measures of empathy in engineering design. To this end, we aim to invite and integrate the perspectives of engineering design instructors and students across multiple disciplines and universities.

Project Overview

The primary objective of this project is to provide the engineering design community with a contextually valid instrument for measuring empathy in undergraduate engineering design contexts. To achieve this objective, we will address the following objectives:

1. To expand and modify a pilot instrument for assessing empathy in engineering design via co-creation with a diverse group of engineering design instructors and student interviews.
2. To test and validate an instrument for assessing empathic formation in engineering design via a multi-methods research design which includes formative feedback from design educators, a pilot student sample, and a large student sample from multiple university sites and disciplines.
3. To identify changes in empathy types across engineering design when applying the instrument in multiple disciplinary design contexts and by accounting for how instructional design contexts and practices influence empathic formation.

We will employ a three-phased research study design to address these objectives, as depicted in Figure 1. Each primary phase includes three subphases. Phase One includes co-creation workshops with engineering design instructors, student contextualization, and instrument design

iterations. Phase Two includes additional co-creation workshops with engineering design instructors, pilot testing a new instrument with students in engineering design courses, and then testing the instrument with a large student sample. Finally, Phase Three involves applying the instrument to understand empathic formation across instructional contexts.

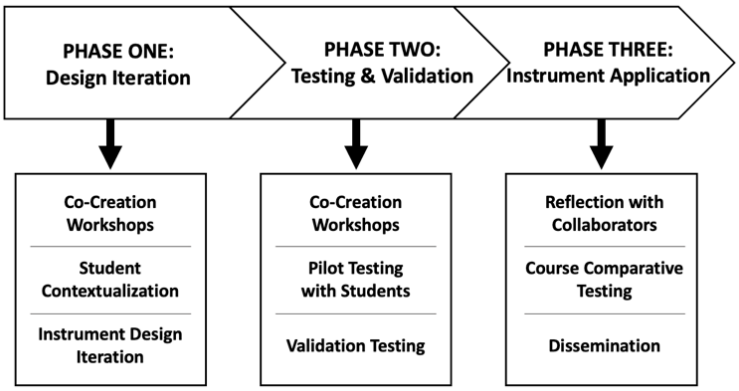

Figure 1. Overview of Research Design

Initial Model for Assessing Empathy

Based on current framings of empathy in engineering design, we acknowledge the critical role that empathy can play in design. Thus, we aspired to develop an instrument accounting for how empathy types manifest uniquely in design contexts. Table 1 provides a list of items associated with three empathy types (*Imagine-Self Perspective-Taking* or *ISPT*; *Imagine-Other Perspective-Taking* or *IOPT*; *Affective Empathy* or *AE*) and specific ways in which these manifest in three design phases: (1) *Needs Finding*; (2) *Concept Generation*; and (3) *Evaluation* ([20]).

Table 1. Pilot Instrument for Measuring Empathy in Engineering Design - taken from [20]

Phase	Type/No.	Subhead
Needfinding Preface: *While reading or hearing about the design scenario:*	IOPT_01	I imagined the users' everyday activities within their real-life context.
	AE_01	I felt sorry for the user experiencing the problem.
	ISPT_01	I imagined how I would feel if I experienced the problem.
	ISPT_02	I felt that I was able to relate to the challenges the users experience in their everyday life.
	ISPT_03	I imagined challenges that I would experience everyday if I were the user.
	IOPT_02	I imagined how the users would feel when they experience the problem.
Concept Generation Preface: *While generating my design ideas:*	IOPT_03	I imagined what design criteria would be the most important to the users.
	AE_02	I felt happy when generating ideas that can be helpful to the users.
	IOPT_04	I imagined how my ideas would look from the users' perspectives.
	ISPT_04	To generate more design ideas, I imagined how I would feel if I were the user.
	ISPT_05	I generated ideas by imagining that I were a user.
	AE_03	I hoped that my ideas would be useful for the users.
Evaluation Preface: *While evaluating my ideas:*	AE_04	I felt concerned when my ideas did not meet the needs of the users.
	ISPT_06	I imagined how I would use my ideas if I were the user.
	IOPT_05	I imagined why the users would like my ideas.
	IOPT_06	I imagined why the users would dislike my ideas.
	AE_05	I felt happy when my ideas helped the users.
	ISPT_07	I imagined what problems I would have when using my ideas if I were the user.
	IOPT_07	I imagined what aspects of my ideas that users would find enjoyable.
	ISPT_08	I evaluated my ideas by imagining that I were the user.

AE = Affective Empathy; ISPT = Imagine-Self Perspective-Taking; IOPT = Imagine-Other Perspective-Taking

We utilized this instrument (i.e., Table 1) to test the hypothesis that empathy types manifest uniquely in discrete design phases [20]. We collected responses with a large first-year engineering student sample and utilized confirmatory factor analysis to test measurement models (1) wherein all items associated with an empathy type loaded onto a single construct representing the type versus (2) measurement models wherein empathy types loaded onto discrete but correlated constructs associated within each design phase. We were able to confirm measurement models aligned with each measurement model configuration, but the latter set of measurement models (i.e., those that account for empathy types within design phases) generally exhibited improved model fit *and* we retained more items on these constructs. As one example in terms of the constructs themselves, we found that Imagine-Other Perspective Taking manifested in Needfinding in unique ways when compared to how Needfinding manifested in in Concept Generation or Evaluation, and thus it was important to account for these empathy types as *three* constructs separated by design phases rather than as a single Needfinding construct that spanned all three design phases.

Iterations on the Instrument as a Key Goal

While this pilot instrument revealed promising evidence of its viability for accounting for how empathy manifests uniquely across engineering design phases, there are several critical directions needed to generate a more robust and comprehensive measure of empathy in engineering design. First, the instrument did not account for variation in design contexts, but we cannot presume that these three design phases nor these three empathy components will be salient in any engineering design context. Second, the instrument may have excluded important design phases. Third, the instrument did not encompass other extant models of empathy in engineering. For example, Walther, Miller, and Sochacka [22] developed a model that conceptualizes how empathy manifests as a skill, orientation, or way of being within engineering, and aspects of this model were largely missing from Table 1.

To address these limitations, we argue that the pilot instrument [20] must account for additional perspectives and, in turn, a more holistic representation of how empathy manifests throughout engineering design. The study begins with the goal of developing a shared and expanded understanding of where and how empathy is salient throughout design via co-creation with design instructors and scholars who are committed to empathy in engineering design.

Co-Creation with Design Instructors and Scholars

To initiate our investigation, we have begun implementing co-creation workshops to better understand the perspectives of design educators. We are engaging in co-creation workshops with 10 design instructors from university sites across the US. Co-creation data will enable us to identify additional perspectives on empathy in engineering design; understand the usability and alignment of the existing instrument with the needs, perspectives, and experiences of a diverse set of design instructors and design students; and revise the instrument to ensure its broader applicability across engineering contexts. Each co-creation workshop tasks participants to reflect before, during, and after the workshop on views of empathy in engineering design. The sessions themselves have involved peer dialogue, critique, and co-construction of empathy models.

At the time of this writing, we have led two co-creation workshops, each including two separate groups based on scheduling needs. As an example, we share the design of the initial co-creation workshop here. The first half of the initial co-creation workshop asked participants to respond to three guiding questions in turn:

1. What is your definition of empathy?
2. How do you view empathy in engineering design in your context?
3. What thoughts do you have after hearing from diverse perspectives?

Collaborators shared individual views and responded to peers' views to each of these questions. Thereafter, we transitioned to a collective modelling activity utilizing Miro's software platform. We prompted participants to consider how, what, when, where, and why questions pertaining to empathic instruction in their design contexts:

- **WHO? -** With whom do you want your students to empathize in engineering design?
- **WHAT? -** What do you think empathy is or looks like in engineering design? Broadly, what do you think the phrase "empathy in engineering design" means in your context?
- **WHEN/WHERE? -** When and where do you want your students to empathize in your engineering design course or curriculum?
- **WHY? -** Why is it important for students to empathize in engineering design in your context?
- **HOW? -** How do you want your students to empathize with others in engineering design?

After individually responding to these questions, we asked participants to develop a shared model of empathy in engineering design. Here, we encouraged participants to engage with and build on peer responses and to verbalize their own thinking while engaging in co-creation.

We observed that generating a collective model in a roughly one-hour time frame was challenging in each group. In the first co-creation workshops, we intentionally did not prompt participants with extant models of empathy in engineering, but many extant frameworks and models were referenced. Notably, participants' discussions often went beyond designer-user relationships as participants discussed interactions between engineering students and their peers, clients, instructors, communities, and the environment.

In our second co-creation workshop, we decided to center discussions and co-creation around designers' empathy with/for users, similar to in the initial instrument. Prior to the second session, we asked participants to narrate how a design team with strong user empathy tends to think, feel, and act in one of their design courses. During the session, we shared an extant model of empathy in engineering design on which the initial instrument was founded, then we invited critique of the instrument and identification of parts missing from their pre-reflection stories. We leveraged Miro and this extant model and asked participants to share their stories within the extant model. We also prompted participants to expand the model, naming parts of the model that failed to capture their pre-reflection stories. In this way, we began prompting participants to help us expand the model to other design phases, other empathy types, or other directions. For example, similar to the first co-creation workshop, some participants focused on empathy within the team, with one participant considering this a predecessor or affordance to empathy with/for users.

Thus, we focused our second co-creation workshop around designer-user empathy. This enabled us to focus the discussion more narrowly and expand the initial empathy instrument more purposefully. Yet, given myriad interests and challenges identified in the first co-creation workshop (and some interests that again manifested in the second), we have begun developing alternative pathways to explore emergent interests. We describe one such example next.

Developing Community

We hoped this project would grow the community of scholars and instructors who are studying empathy and engineering design in engineering education. To this end, we have observed and encouraged novel lines of research growing from our co-creation workshops and associated discussions. One example involves our emergent research focus on 'tensions' evident in the first co-creation workshop. As we framed the first co-creation workshop discussion around empathy *without* imposing directionality (i.e., we did not prompt participants to only discuss empathy by students towards users), the focus of the discussion naturally varied.

The discussion in the co-creation workshop considered (1) users or more macro-level stakeholders (e.g., communities, environment) and (2) empathy between peers or between students and instructors. Rather than foreclose this interest, we initiated a pathway to focus on the tensions in how the engineering education community speaks about empathy in engineering design, which we will present at the Harvey Mudd Design Workshop in 2023 [23]. We have begun to explore these tensions through collaborative inquiry research methodology [24] where individuals who are involved in a similar practice (e.g., integrating empathy into engineering design learning experiences) pursue a shared question of interest to build new knowledge and connections to inform their practice.

At the time of writing, five members of the research team and three collaborators have held several meetings to discuss, uncover, and collaboratively define tensions with teaching empathy in engineering design. All participant-researchers have experience teaching engineering design across different levels, majors, and contexts within undergraduate education. Our discussions have led to a model comprised of four key considerations with tensions emerging within or across the four considerations: (1) **definition**, or what counts as empathy or definition, (2) **value**, or how empathy is valued in engineering design instruction, (3) **manifestation**, or how empathy manifests in engineering design, and (4) **pragmatic**, or how instructors might support students engaging in empathy in their engineering design courses. We believe these conversations allow for not only a more encompassing exploration of empathy and its role in engineering design, but have also started to strengthen the community and reap new insights into the design and validation of an instrument to measure engineering students' empathy with/for users.

Conclusion

In this project, we aim to iterate on an instrument for assessing empathy with a diverse group of engineering design instructors to improve its alignment with their unique disciplinary contexts. We will collect student data to ensure that any instrument refinements accurately represent student experiences. We will test the revised instrument for validity via the triangulation of quantitative and qualitative data with a small student sample followed by a large student sample.

We will also use the instrument to identify differences in empathic formation associated with various instructional design contexts and practices, thus generating new knowledge on best practices for promoting empathic formation in engineering design. Finally, we will continuously pursue new collaborative opportunities, with the goal of growing and supporting the community of instructors and scholars interested in studying empathy in engineering design.

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