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WIP: Developing Rasch/Guttman Scenario Scales towards an Empathy in Design Instrument

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WIP: Developing an Empathy in Design instrument using Rasch/Guttman Scenarios

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Introduction

This work-in-progress method paper presents initial efforts toward developing a scenario-based instrument to measure empathy in engineering design. Empathy is a multifaceted phenomenon that involves seeking to understand another's thoughts and relating to another's emotions [1], [2], [3] and has been conceptualized as a learnable skill that can be developed and embedded in design pedagogy [4], [5]. Empathy is increasingly recognized as an important part of engineering education, particularly in design, as it can enable one to effectively meet user needs and can provide the "spark of human concern" for users [6], [7], [8], [9]. Developing empathy in engineering graduates is critical to preparing students to engage in a globalized society, to create inclusive engineering solutions, and to engage students who aspire to help others and to promote a socially just world [10], [11], [12].

Despite the growth of interest in empathy in engineering and design, there is no contextually valid approach for quantitatively measuring empathy. As a result, we lack robust ways to accurately identify the impacts of engineering design instruction on empathic formation. This paper presents initial work on an instrument that utilized Rasch/Guttman Scenario Scales to develop rich, situational scenarios to measure empathy across four unique design phase constructs so instructors can quickly assess their students' empathic development across design. This work-in-progress paper establishes the need for a scenario approach to instrument development for empathy in engineering design, introduces Rasch/Guttman Scenario Scale development methodology [13], describes the steps we have completed, and establishes future direction for this work towards the creation and testing of this new scenario instrument.

Empathy in Design

Empathy has been characterized as an integrated and internal process that is supported by personal and contextual factors and that informs intrapersonal and interpersonal outcomes [1], [2], [3]. Engineering design serves as a disciplinary context that impacts how empathy is developed as a skill, enacted through processes, and both contribute to and emerge as outcomes. We conceptualize empathy as an embedded process within select phases of the design process, including understanding users, identifying requirements, generating concepts, and evaluating solutions [14], [15], [16], [17]. Each of these design phases acts as a different lens through which empathy in design can be contextualized and wherein different processes, outcomes, and empathy types can emerge.

This work leverages a two-dimensional framework of empathy in design toward developing a scenario-scale instrument [11], [14] that includes the affective-versus-cognitive domains and self-versus-other orientation. Empathy accounts for ways of understanding, relating to, or feeling as a result of the thoughts or feelings of another and has been categorized as having at least eight distinct phenomena, or empathy types [1], that vary across these two dimensions [2], [14], [18]. Figure A1 in the appendix illustrates this two-dimensional framework for empathy in design that depicts four empathy types associated with the four main quadrants of domain and orientation. The affective-cognitive domain dimension describes how empathy manifests as a change to one's emotional state as one feels with or for another (affective) and develops an awareness or understanding of another's thoughts, feelings, or experiences (cognitive) [19], [20]. The self-other orientation dimensions add directionality to affective and cognitive empathy in how one experiences their emotions and understandings as either directed inwardly towards the self or outwardly towards others [20]. This two-dimensional empathy framework is flexible enough to cover many empathy types, specific enough to distinguish them, and allows for multiplicity in empathy types in a design phase. Accordingly, a later revision to the model emphasized the quadrants themselves rather than the select empathy types embedded within quadrants (refer to Figure A2).

Measuring Empathy in Design

While numerous measures of empathy exist [2], [19], [21], these instruments tend to conceptualize empathy as a general trait or tendency that exists broadly. However, within specific contexts such as the disciplinary context of engineering, empathy manifests uniquely as compared to general encounters [5], [6]. Previously work had developed and tested an instrument to explore how empathy types emerge in different engineering design phases [15], [18], which supported the theory that empathy manifests uniquely across design phases. Specifically, research has shown that individual engineers can vary in their use and intensity of empathy types [22]. For example, one can strongly employ self-oriented affective empathy but minimally become concerned for others or imagine their perspectives. While this prior instrument revealed promising evidence of its viability for accounting for how empathy manifests uniquely across engineering design phases, it does not account for variation in design contexts, nor does it wholly represent novel perspectives of empathy in engineering. Moreover, the prior instrument leveraged a traditional Likert-type instrument to explore empathy in design. While Likert-type scales are useful for understanding the intensity of attitudes, beliefs, and perceptions, they are not ideal for investigating progressive or hierarchical phenomena like that of empathy in design. Scenarios are proposed for items that better support participants in engaging in critical reflection and cognitive processing. This work utilizes the Rasch/Guttman Scenario (RGS) Scale Methodology as an approach to scale development that uses rich hypothetical situations to assess respondents' attitudes and behaviors, including those that embed progress and hierarchy relationships too complex for Likert-type scales [13].

Instrument Design Methodology

RGS is an approach to scale development for progressive constructs. RSG is guided by Rasch measurement principles [23] and Guttman facet theory design [24], [25], [26], which together guide the generation of scenarios to measure progressive phenomena. Rasch measurement principles serve as an a priori foundation to identify constructs and guide scale development. Rasch principles dictate that scale items must (a) measure a single construct, (b) measure a range of levels of the construct, (c) spread uniformly across the construct continuum, (d) measure the increasing progress of the construct, (e) have the same relationship to the construct, (f) that one response to an item is not dependent on the response of another, and (g) that theory and data match [23], [27]. Guttman Facet Theory provides conceptual clarity and a systematic, transparent, and reproducible approach to develop scenarios by mapping a construct's facets and structs (i.e. levels). Together, Rasch's principles and Guttman Facet's theory design approach to mapping supports the development of rich and plausible "lived experience" scenarios.

This work leverages a seven-step methodological framework to systematically construct and test scenario scales [13]. These steps include: 1) defining the constructs, 2) determining facets and generating descriptions, 3) determining facet levels and generating descriptions, 4) determining the structure of the scenarios, 5) developing the mapping sentence and constructing the scenarios, 6) deciding on survey format, and 7) testing congruence of theory and practice.

Presently, the research team has completed work through step three. This section presents the completed steps followed by a brief overview of the remaining steps in the future work section.

Step 1: Define the constructs

The first step is to identify and define the constructs to be understood using scenario scales [13]. It is important to thoroughly understand the lived experiences associated with this construct to be able to describe a person who embodies the construct at an “upper level,” “middle level,” and a “lower level.” To do this, the team reviewed the existing literature, included three content experts (authors 3, 4, and 5) who have engaged in a series of investigations to understand empathy in design [4], [14], [15], [18], and leveraged interviews from 28 students who engaged in a wide range of engineering design courses and projects. Building from these investigations, we met weekly throughout the fall 2024 semester evaluate what constructs supporting empathy are of particular importance for further understanding in engineering design. We discerned four constructs that support understanding empathy in design across four design phases including understanding users, setting requirements, concept generation, and solution evaluation.

Step 2: Determining facets and generating descriptions

The second step includes the identification of the main facets of the constructs. Guided by Guttman Facet theory, these facets are a set of distinct elements, characteristics, and attributes that classify the construct(s) of interest [24], [26]. In this work, we identified and defined four facets that represent empathy in combined domains of self vs. other orientation and affective vs. cognitive orientation [14], [18]. Each facet is illustrated by a quadrant in Figure A1 in the appendix and includes empathic distress/pleasure, empathic concern/joy, imagine-self perspective taking (ISPT), and imagine-other perspective taking (IOPT).

Step 3: Determine facet levels and generate descriptions

The third step is to delineate structs, or gradations, to represent low to high ranges within each facet. Derive from Guttman Facet theory, these structs represent hierarchical levels of structure used to look across the facets of each construct [24], [26]. Three structs are recommended as a pragmatic starting point which focus on low, moderate, and high levels of each facet. The structs in this work represent someone who is highly empathetic, moderately empathetic, and not very empathetic with regard to a specific facet of empathy. After structs are identified, facet structs are denoted for each facet at each struct. In this work using four facets per construct, there are 12 facet structs per construct; with four constructs that resulted in 48 total facet struct combinations to be defined. All authors worked together to (1) describe each facet struct with a consideration and (2) discern how the levels in each facet be described in parsimonious ways while reflecting the nuance evident across theoretical understandings of the facet, the team’s research expertise, and the emergent results of the qualitative data associated with the instrument design. To form these descriptions with this level of nuance, authors 1 and 2 sought to elicit perspectives of the content experts to discern difference between the 48 facet structs, and then the team negotiated framing of structs for clarity, parsimony, and import for retention.

Results

Presently, the research team has defined all 48 facet structs. **Error! Reference source not found.** presents an example of three of the 12 total description of facet structs for the User Understanding Construct for the Empathic Distress/Pleasure facet at the three structs. Each description is purposefully short and emphasizes particular actions, details, and emotions that represent the lived experiences of someone who reflects that level of empathy in a respective empathy domain.

For example, as reflected in Table A1 in the appendix, some details that separate the high, moderate, and low structs include 1) the intensity of their emotions, 2) the degree of connectivity to the users, and (3) the drive to help users. The delineation between structs varies in each set of facet structs for a design phase and include additional variations on breadth versus depth, emotions, directionality of emotions, and associated actions or reactions.

Future Work

Following the seven-step scenario development framework [13], the team needs to complete the final four steps. The team is currently working on Step 4, determining the structure of the scenarios. For each construct, struct level descriptions will be shortened and combined into scenarios, and each construct 81 possible combinations of the four facets at the three different struct levels. These many possible scenarios are not practical, and all struct combinations do not represent realistic representations of the construct. Currently, the research team is in the process of selecting meaningful combinations to identify five to seven options for each construct. Limiting the number of scenarios helps reduce respondent fatigue while still having enough scenarios to hierarchically illustrate each construct.

For Step 5, the team needs to develop the mapping of sentences and construct the scenarios. This process distills the facet struct descriptions into sentences that follow a mapped template derived from the different intensities of specific elements of the facet struct descriptions. Per the combinations determined in Step 4, the sentences are then combined into full scenarios and revised with readability and user engagement in mind. Following Step 6, the team will decide on the response options and survey instructions to support students in engaging with a novel item format while reducing response bias. Finally, Step 7 includes testing the congruence of theory and practice by engaging with appropriate reviewers including engineering design faculty and engineering students. This will include small-scale administration paired with qualitative data collection followed by a larger pilot stage with the target population. review with design instructors, interviews with students, and a larger quantitative pilot to test how the scenarios support balanced variable maps. Depending on how the variable maps align with the hypothesized scale structure, the scenario items may be altered to strengthen the utility of the scale. Ultimately, this work will produce a more robust measure of empathy in engineering design by creating sets of scenario questions for each construct that will enable instructors to better understand how empathetic their engineering students are in different design phases.

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Appendix

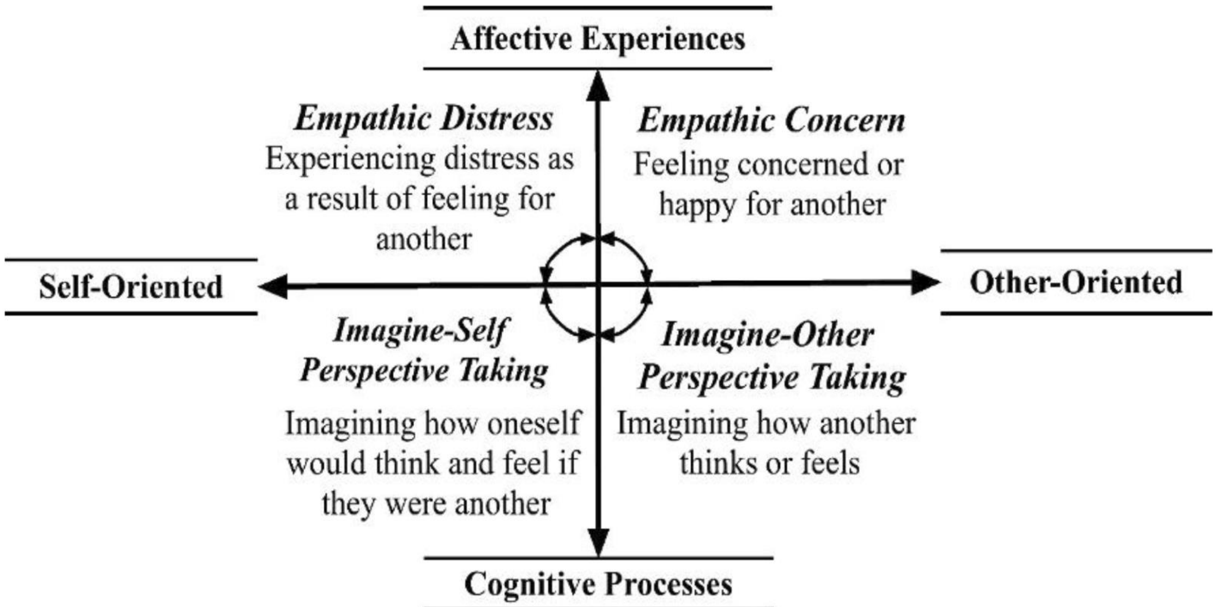

Figure A1: Four-Part Empathy Model (taken with permission from [4, Fig. 1])

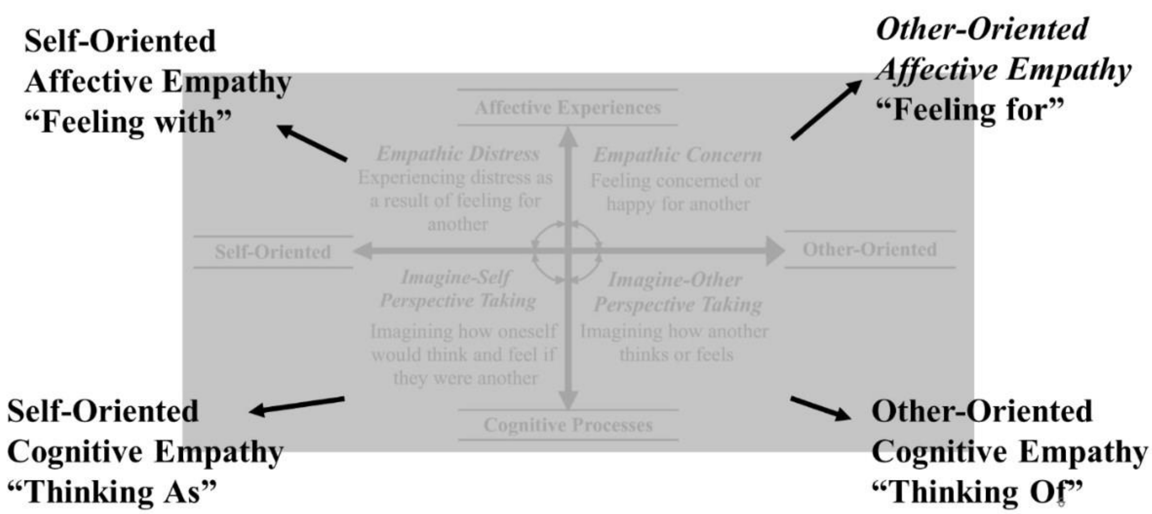

Figure A2: Four-Part Empathy Model (taken with permission from [18, Fig. 2])

Table A1: Facet struct descriptions for empathic distress/pleasure for the construct Understanding Users

Facet	**Struct**	**Facet Struct Description**
Empathic Distress/ Pleasure	High	A highly empathic individual in this domain experiences strong emotions when they think about what it must be like for the users to experience the problem. These emotions tend to be negative and are directed inward as they have a strong level of connectivity to the users and as they feel the weight of their problems. These feelings of distress and connection lead to the person feeling invested in helping the users and that the solution they design must solve the problem.
	Moderate	A moderately empathic individual in this domain experiences mild emotional response when they think about others experiencing a problem. These emotions are directed inward and are negative, which emerges as feeling frustrated or upset that a solution for a problem does not yet exist. These feelings are slightly motivating as the person wants to try and make a solution that is helpful to the end users.
	Low	Someone who is not very empathic in this domain thinks about the people they are designing for but does not experience positive or negative emotions that drive their investment in solving the problem. They express a desire for their engineering design projects to be generally useful but are not connected to the specific users they are designing for.