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Quantifying Interpersonal Tendencies of Engineering and Science Students: A Validation Study*

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Engineering and science programs seek to foster a wide range of skills among students, including a myriad of professional skills. This study describes the design of two survey constructs that align with many important professional skills, Interpersonal Self-Efficacy and Emotion Regulation. We validate these constructs alongside two prominently used empathy constructs: Perspective-Taking and Empathic Concern. By validating these constructs, this study provides educators with an easily implementable and trustworthy means of ascertaining changes in student growth resulting from their own curricular interventions. As a first step in this study, the constructs' componential structures were defined. Second, confirmatory factor analysis was employed to identify the fit of the factor structures. Third, Pearson bivariate correlations were examined to ascertain relationships between constructs. The results indicate that, with modification, each construct was structurally valid. While Interpersonal Self-Efficacy and Emotion Regulation showed moderate relationships with Perspective-Taking and Empathic Concern, Interpersonal Self-Efficacy exhibited the strongest overall correlations. Constructs componential structures are used to help explain findings and to provide concrete insights into the nuances between phenomena. These findings can facilitate future explorations on engineering and science students' professional formation.

Keywords: confirmatory factor analysis; correlation analysis; emotion regulation; interpersonal self-efficacy; empathy; biomedical engineering; earth science

1. Introduction

Engineers and scientists require a wide range of skills and dispositions if they are to be prepared to act effectively and ethically in their careers [1, 2]. Universities serve as the training grounds for students as they participate in the process of becoming professionals in their respective disciplines [3]. Hence, there are numerous calls for the enhancement of students' development of professional skills. Such skills are applicable in numerous contexts, such as problem-solving, ethics, and communication [1, 2, 4], to name a few. For example, more than ten years ago, the National Academy of Engineering argued, "Engineers need to work in teams, communicate with multiple audiences, and immerse themselves in public policy debates and will need to do so more effectively in the future" [1, p. 43]. It is expected that students build these foundations during their academic tenure.

Given an ongoing emphasis on science and engineering students' professional development throughout the United States, strategies for measuring and evaluating the impact of higher education on students' professional formation continues to be of critical importance. Specifically, universities and instructors require valid strategies for ascertaining the extent to which their students have achieved the myriad of expected learning goals and outcomes, including those in the "professional" domain [2, 5]. This study focuses on the design, measurement, and validation of two constructs representing two professional skills that we believe are central to the formation of engineers and scientists: interpersonal self-efficacy and emotion regulation. As these two skills are aligned with (and potentially foundational to) many other expected outcomes of engineering and science students' undergraduate education, validated methods for ascertaining students' growth in these domains are needed.

In addition, socio-emotional competencies are increasingly being recognized as foundational to engineering students' professional development, such as emotional intelligence [6] and empathy [7, 8]. Yet, individual socio-emotional competencies are highly nuanced and complex and, as a result, difficult to measure. For example, empathy has no less than eight distinct conceptualizations in the social neuroscience literature [9]. To help measure these phenomena, socio-emotional competencies can be further defined by their constituent parts, or what we call their componential structure. Aspects of this structure may, in turn, possess subcomponential structures. To continue with the empathy example, Decety and Moriguchi [10] described four core components of empathy: (a) affective sharing; (b) self-awareness; (c) mental flexibility; and (d) self-regulation. In turn, self-

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regulation includes several underlying components, such as (a) delay of self-gratification, (b) emotion regulation, and (c) decision-making in light of complexity [11]. Hence, to develop a holistic understanding of empathy, we need tools to measure its underlying features (i.e., emotion regulation).

While there are numerous constructs that measure professional and socio-emotive skills, such as empathy [i.e., 12, 13] and communication [i.e., 14], there are few psychometric instruments that measure interpersonal self-efficacy and emotion regulation. Furthermore, while STEM instructors can utilize psychometric instruments developed and validated outside of the context of engineering and science education, these constructs may require additional validation checks in situ prior to wide-scale adoption. This is because socio-emotive constructs borrowed outside of science and engineering may not exhibit the same properties when used with engineering and science students. For example, the Interpersonal Reactivity Index [13] has been used by multiple authors to measure engineering students' empathic development [15–17], but the IRI was validated outside of engineering. Hence, factor analytic procedures need to be used to confirm that these constructs are structurally valid when situated in the context of science and engineering.

1.1 Study purpose

This study involves the development and validation of two survey constructs, as well as an analysis of how these constructs relate to Empathic Concern and Perspective-Taking as measured by the Interpersonal Reactivity Index [13]. The primary objectives of this study are threefold. First, we seek to identify the componential structure of Interpersonal Self-Efficacy, Emotion Regulation, Perspective-Taking, and Empathic Concern and, guided by this componential structure, design questions (or survey items) matched to this structure. Second, we aim to use Confirmatory Factor Analysis to ascertain the structural validity of the constructs. Third, through correlation analyses, we will examine inter-construct relationships.

By validating these constructs, this study will provide engineering educators with an easy to use and trustworthy means of ascertaining changes in student growth resulting from their own curricular interventions. For example, in the future, our team aspires to utilize the validated constructs to ascertain students' interpersonal development resulting from participation in courses that integrate community-engagement and ethical reflection [18]. Likewise, engineering education researchers are currently using similar instrumentation, such as the Interpersonal Reactivity Index, to identify students' empathic development resulting from courses in service-learning [15], design [16], and ethics [17].

2. Literature review

2.1 Interpersonal self-efficacy

Throughout the United States, scholars have emphasized the need to focus on students' development of interpersonal skills. In 2012, the National Research Council defined eight constructs that are representative of cognitive (i.e., processes and strategies, knowledge, creativity), intrapersonal (i.e., intellectual openness, work ethic/conscientiousness, positive core self-evaluation), and interpersonal (i.e., teamwork and collaboration, leadership) competencies [19]. More recently, Herman and Hilton [20] called for the support and assessment of intrapersonal and interpersonal competencies. In this report, they described interpersonal competencies as ''expressing information to others as well as interpreting others' messages and responding appropriately'' (p. 1). This succinct definition encapsulates several nuances, which may be described as separate skills or even sub-skills. For example, *expressing information* describes an outward communicative act; *interpreting others' messages* involves the reception of others' communicative acts; and *responding appropriately* involves synthesizing that information and using it to generate a response. More pointedly, Seal, et al. [21] described personal-interpersonal competence as encompassing four related components: self-awareness, consideration of others, connection to others, and orientation to seeking change. Self-awareness and consideration of others are tied together by Seal et al.'s *connection to others* construct.

In this study, we aspired to measure interpersonal self-efficacy in a manner that encapsulated the nuances described above. In the design of this construct, we operationalized interpersonal self-efficacy as the ability to successfully interact with others, including others who may have perspectives that diverge from one's own, and committing one's self to bearing in mind these external perspectives when finalizing a decision. Through this study, we sought to develop a structurally valid group of items that accurately represent this construct as operationally defined here. Importantly, we slightly adapted three items from Seal et al. [20]. Furthermore, in alignment with Davis [13], we theorized that this construct would be related to Perspective-Taking, Empathic Concern, and Emotion Regulation.

2.2 Emotion regulation

Emotion regulation refers to one's ability to manage

emotions in stressful encounters. As Lopes et al. [22] stated, ''Definitions of emotion regulation vary considerably'' (p. 712). A leading researcher on emotion regulation is Nancy Eisenberg [23, 24]. In 2004, Eisenberg and Spinrad stressed three core distinctions that scholars need to articulate when defining emotion regulation [23]. First, some definitions focus on emotion as a regulator whereas others depict emotion as the target of self-regulation. For example, social interactions may produce emotions (i.e., anger) that, in turn, produce or inhibit another disposition or ability. Alternatively, emotion regulation may represent the ability of the self to regulate an emotion (this latter definition was favored by the authors). Second, definitions must distinguish between the self's internal regulation of emotions versus externally imposed regulation of emotions. The authors suggested that this dichotomization represents two distinct and equally valid forms of emotion regulation. Our intent in the design of the emotion regulation construct aligned with the former. Third, Eisenberg and Spinrad [23] indicated that emotion regulation can vary based on whether or not there is a goal in mind. For example, in the context of science and engineering, self-emotion regulation may operate differently when it involves brainstorming possible solutions, as opposed to team-building activities, experimenting in the lab, or communicating ideas to stakeholders.

Emotion regulation is distinct but interrelated with empathy [13]. Decety and Moriguchi indicated that ''individuals who can regulate their emotions are more likely to experience empathy'' [10, p. 11]. In other words, if one lacks emotion regulation skills, when encountering stress or complexity, they may experience what Hoffman [25] referred to as ''empathic over-arousal'' where their mind shifts to a ''preoccupation with their own personal distress'' (p. 13). This preoccupation, in turn, inhibits their empathic potential. Importantly, in Hoffman's framework, empathic distress is essential for motivating empathic and prosocial behavior *insofar* as it does not surpass a threshold leading to empathic over-arousal, where an individual's emotion regulation skills dictate the capacity of that threshold. Hence, the ability to regulate emotions during stress encounters makes it possible for a range of other skills to operate, such as interpersonal self-efficacy and perspective-taking, but it does not ensure their operation. Contrariwise, the inability to regulate one's emotions nearly ensures that, when faced with stress or adversity, one will not utilize certain interpersonal skills, such as those mentioned above.

In this study, we were interested in the self's ability to regulate emotions during the process of solution-development, particularly when this process involves uncertainty and complexity. In alignment with Decety and Moriguchi [10], we theorized that this ability would be correlated with Interpersonal Self-Efficacy, Perspective-Taking, and Empathic Concern.

3. Methods

3.1 Design of survey constructs

Constructs representing Interpersonal Self-Efficacy and Emotion Regulation were designed through a series of steps. First, a review of pertinent literature and instrumentation was conducted. Second, an operational definition of each construct was generated. Third, the core components of each construct, or what we refer to as a construct's *componential structure*, were identified. Fourth, questions from existing instruments were adapted in alignment with this componential structure and, as applicable, new questions were designed. Importantly, the items from the Interpersonal Reactivity Index (Perspective-Taking and Empathic Concern) were utilized verbatim as described in Davis [13].

The constructs developed and reported in this study involve self-report data. While self-report data may contain biases that can be potentially influenced by social norms or how one feels at the time of survey completion, it remains one of the most common strategies for evaluating individual dispositions or values [19]. We used a nine-point Likert-type scale where the end-points were defined (1 = ''Strongly Disagree'' and 9 = ''Strongly Agree'') and all items in-between represented a continuum from strong disagreement to strong agreement. The research team chose to use a nine-point Likert-type scale to increase the likelihood for ascertaining changes when utilizing these constructs as part of an intervention.

3.2 Data collection

The authors' university's Institutional Review Board approved the use of the instrumentation reported in this study. Instructors of each of the courses were contacted and asked for permission to disseminate the survey to their students at the start and end of the Fall 2017 academic semester. The instruments were then administered online using Qualtrics survey software. The start-of-semester data is relied upon for this investigation. Furthermore, the measures described in this study were administered alongside other instruments, including the Civic Minded Graduate Scale [26] and the Defining Issues Test-2 [27]. Data from these two instruments are not reported here.

Participants included 207 students recruited from various Biomedical Engineering and Earth Science courses at a public university in the mid-western

Table 1. Demographic Information of Participants

Category	Sample	Relative %
Total	**207**	**100.0**
Gender		
Male	94	45.4%
Female	113	54.6%
Not Specified	1	0.5%
Race/Ethnicity		
White	148	71.5%
Hispanic/Latino	12	5.8%
Black/African American	12	5.8%
Asian	6	2.9%
Multi-Racial	11	5.3%
Nonresident Alien	16	7.7%
Not Specified	2	1.0%
Academic Standing		
Freshman	45	21.7%
Sophomore	44	21.3%
Junior	51	24.6%
Senior	61	29.5%
Not Specified	2	1.0%
School		
Engineering & Technology	89	43.0%
Science	56	27.1%
Liberal Arts	18	8.7%
Education	17	8.2%
Other	18	8.7%
Not Declared	5	2.4%
Not Specified	4	1.9%

United States in the Fall of 2017. Participants were primarily in the Schools of Engineering and Technology ($n = 89$, 43%) and Science ($n = 56$, 27%). The sample included 94 males (45%), 113 females (55%), and one student who did not specify sex. Participants' racial backgrounds were primarily White ($n = 148$; 72%). Participants varied widely in terms of academic standing, including 45 freshman (22%), 44 sophomores (21%), 51 juniors (25%), and 61 seniors (29%). Table 1 provides a summary of participant demographics.

3.3 Data analysis

First, an operational definition and componential structure guided the development and/or adaptation of items for each construct. Descriptive statistics, including item means and standard deviations, were computed for each survey item by using Stata/IC version 14.2. Next, outliers, skewness, and kurtosis were measured and examined to depict the distribution of responses. We then computed and examined the inter-item Pearson correlation matrices [28]. This revealed multiple coefficients with a moderate relationship [i.e., $r > 0.30$, 29] supporting factorability of the data [30] for each of the survey constructs.

Second, we conducted confirmatory factor analysis (CFA) using Stata/IC version 14.2. CFA deals with "restricted measurement models" [28]. The key assumption of CFA, met with each of the constructs modelled herein, is that each factor includes at least three indicators whose error terms are not correlated with one another [28]. CFA further assumes that each observed variable (also known as effect indicator) has two causes: an error term and a single factor. Generally, these error terms are assumed to be independent of one another as well as of the other factors, but interdependence of error terms (i.e., allowing the error terms to correlate) can be included in the model to improve overall fit.

Global model-data fit was evaluated by examining the Satorra-Bentler (S-B) chi-square test statistic and other goodness-of-fit statistics. Good model fit is inferred if there is a failure to reject the null hypothesis of the chi-square test, which tests the hypothesis that the data are significantly different than the imposed model. We sought select thresholds for various fit statistics, including a Tucker-Lewis Index greater than 0.95 and a root mean squared error approximation statistic less than 0.10 [31]. Specific items that did not fit these objectives were re-evaluated and subsequently modified or, if necessary, deleted to attain a better model fit. The factor loadings displayed in the *Results* section of the manuscript are standardized coefficients from the respective model. Therefore, changes in relationships between items refers to standard deviations rather than actual values from the instrument. Following the CFA, individual scores to each respective construct, each item's factor loading (see Figs. 1–4) were multiplied by the observed response, and these scores were summed and then normalized so that all constructs were on the initial 9-point Likert-type scale.

Finally, we investigated relationships between Interpersonal Self-Efficacy, Emotion Regulation, Perspective-Taking, and Empathic Concern by using Pearson product-moment correlations. Pearson correlation provides an estimate of the "linear association between two continuous variables" [28]. We used an alpha level of 0.01 to denote statistically significant relationships between constructs. By adopting this more conservative measure (i.e., rather than 0.05), we sought to avoid committing a Type 1 error.

4. Results

4.1 Survey constructs

4.1.1 Interpersonal self-efficacy

We operationalized Interpersonal Self-Efficacy as *the ability to successfully interact with others, including others who may have perspectives that diverge from one's own, and committing one's self to bearing in mind these external perspectives when finalizing a decision*. This construct included four primary components: (1) Awareness of self; (2) Awareness of

Table 2. Interpersonal Self-Efficacy (ISE) Survey Items

Label	Item Description
ISE01	I feel prepared to work with people who define a problem differently than I do.
ISE02	I consider another person's perspective before making a decision.
ISE03	I am prepared to meet and work with individuals from different backgrounds.
ISE04	I value opinions that are different from my own.
ISE05	I am generally able to understand the viewpoints of others.
ISE06	Before finalizing a decision, I like to gather feedback from others.

Note. Responses ranged from 1 (*Strongly Disagree*) to 9 (*Strongly Agree*).

other; (3) Comfort with relation between self and other; and (4) Commitment to diversity of thought.

The construct was developed by borrowing and adapting items from Seal, et al. [21], Downey, et al. [32], and Hess et al. [45] that were aligned with these components. Table 2 lists each survey item. Six items were designed or modified to measure self-perceived Interpersonal Self-Efficacy. Each item contained a reference to self (e.g., "I feel . . .", "I am prepared . . .") as well as a reference to others (e.g., "work with people who . . .", ". . . viewpoints of others."). Each item contained a verb indicating one's self-tendency to think or act in a specific manner (e.g., "I like to gather . . .", "I value opinions . . ."), specifically, in light of others. Half of the items emphasized difference in self and other, and half of the items emphasized self-other considerations without any emphasis on difference.

Table 6 provides descriptive statistics for each Interpersonal Self-Efficacy (ISE) survey item. The most positive responses were to ISE03 (M = 7.41, SD = 1.65) and the least positive responses were to ISE02 (M = 6.44, SD = 1.71). All items showed standard deviations greater than 1.60 but less than 1.75. Each item was moderately skewed to the left and was approximately non-normal. The inter-item correlations were all greater than 0.30, indicating medium ($r > 0.30$) to large ($r > 0.50$) effect sizes [29]. The strongest correlations were between ISE04/ISE05 (r = 0.65) and ISE03/ISE04 (r = 0.65). The weakest correlation was between ISE01/ISE06 (r = 0.38). Table 2 provides all item descriptions.

Table 3. Emotion Regulation (ER) Survey Items

Label	Item Description
ER01	When I cannot find the right solution to a problem, I tend to remain calm.
ER02	When dealing with complexity, I feel at-ease.
ER03	I sometimes feel helpless when I am working on a very complex issue. (–)
ER04	I tend to lose control when I cannot find the right answer to a problem. (–)
ER05	I don't shy away from complicated problems.
ER06	I tend to lose control when faced with several competing issues at once. (–)

Note. Responses ranged from 1 (*Strongly Disagree*) to 9 (*Strongly Agree*); (–) denotes negatively worded items that were reversed prior to analysis

4.1.2 Emotion regulation

We operationalized Emotion Regulation as *the ability to regulate emotions when faced with uncertainty and complexity while developing solutions or responses to a problem*. Specifically, this construct included four core components: (1) Awareness of self; (2) Comfort with complexity; (3) Acceptance of uncertainty; and (4) Ability to cope with stress.

To design this construct, we adapted items from the Personal Distress subscale designed by Davis [13] and the Confidence construct designed by Hess et al. [45]. Six items were initially used (see Table 3). Each item contained a reference to self (e.g., "I sometimes . . .", "I tend to . . .") as well as a reference to uncertainty or complexity (e.g., ". . . complicated problems.", ". . . competing issues . . ."). All items included terminology related to coping with (or failing to cope with) emotions (e.g., ". . . remain calm.", ". . . feel helpless . . ."). Three items embedded the term "problem," two embedded the term "issue," and one item did not explicitly reference either. Nonetheless, all items emphasized either complexity or uncertainty. Three items were negatively worded and their scores were reversed prior to analysis (i.e., responses of "9" were changed to "1"; responses of "8" were changed to "2").

Table 7 provides descriptive statistics for each Emotion Regulation (ER) survey item. The most

Table 4. Perspective-Taking (PT) Survey Items [taken from 13]

Label	Item Description
PT01	I sometimes find it difficult to see things from the "other guy's" point of view. (–)
PT02	I try to look at everybody's side of a disagreement before I make a decision.
PT03	I sometimes try to understand my friends better by imagining how things look from their perspective.
PT04	If I'm sure I'm right about something, I don't waste much time listening to other people's arguments. (–)
PT05	I believe that there are two sides to every question and try to look at them both.
PT06	When I'm upset at someone, I usually try to "put myself in his shoes" for a while.
PT07	Before criticizing somebody, I try to imagine how I would feel if I were in their place.

Note. Responses ranged from 1 (*Strongly Disagree*) to 9 (*Strongly Agree*). (–) denotes negatively worded items that were reversed prior to analysis.

Table 5. Empathic Concern (EC) Survey Items [taken from 13]

EC01	I often have tender, concerned feelings for people less fortunate than me.
EC02	Sometimes I don't feel very sorry for other people when they are having problems. (–)
EC03	When I see someone being taken advantage of, I feel kind of protective towards them.
EC04	Other people's misfortunes do not usually disturb me a great deal. (–)
EC05	When I see someone being treated unfairly, I sometimes don't feel very much pity for them. (–)
EC06	I am often quite touched by things that I see happen.
EC07	I would describe myself as a pretty soft-hearted person.

Note. Responses ranged from 1 (*Strongly Disagree*) to 9 (*Strongly Agree*). (–) denotes negatively worded items that were reversed prior to analysis.

positive responses were to ER05 (M = 6.33, SD = 1.80) and the most negative responses were to ER04 (M = 4.17, SD = 2.17). All items showed standard deviations between 1.80 and 2.20. Most survey items were minimally to moderately skewed to the left, with the exception of ER03. While several inter-item correlations were greater than 0.30, many were not (see Table 7). Specifically, ER04 exhibited weak to no correlations with multiple items (i.e., ER02, ER05), although it also had the strongest correlation with ER06 (r = 0.60).

4.1.3 Perspective-taking

Davis's [13] Interpersonal Reactivity Index (IRI) is a self-report psychometric instrument grounded in social psychology literature. It measures self-reported empathic tendencies through four subscales: (i) Fantasy, (ii) Perspective-Taking, (iii) Empathic Concern, and (iv) Personal Distress. Perspective-Taking was borrowed directly from Davis's IRI. Perspective-Taking represents one's tendency to consider the perspectives of another or others in general everyday interactions. We describe Perspective-Taking as cognitive, meaning its focus is on mental processes and rational thought, as well as other-oriented, meaning it involves a focus on the mind of another [25]. Tables 4 lists the seven survey items for Perspective-Taking.

Table 8 provides descriptive statistics for each Perspective-Taking survey item. The most positive responses were to PT05 (M = 7.02, SD = 1.67) and the most negative responses were to PT04 (M = 5.59, SD = 2.12). All items showed standard deviations between 1.67 and 2.12. All survey items were moderately skewed to the left. While several inter-item correlations were greater than 0.30, many were not (see Table 8). PT04 consistently exhibited the weakest inter-item correlations, and only exhibited one inter-item correlation above 0.30.

4.1.4 Empathic concern

As with Perspective-Taking, we borrowed Empathic Concern items directly from Davis's Interpersonal Reactivity Index. While we described Perspective-Taking as primarily cognitive, we describe Empathic Concern as affective, meaning its focus is on emotions [13]. We conceptualize Empathic Concern as other-oriented, as well, but here there is also a focus on the self's internalized emotions resulting from a relation between self and other [33]. Table 5 lists the seven Empathic Concern survey items.

Table 9 provides descriptive statistics for indivi-

Table 6. Descriptive Statistics and Inter-Item Correlations for Interpersonal Self-Efficacy Items

Item #	*M*	*SD*	Skew	Kurtosis	ISE01	ISE02	ISE03	ISE04	ISE05	ISE06
ISE01	6.75	1.62	–0.60	3.11	1	0.53	0.58	0.62	0.56	0.38
ISE02	6.44	1.71	–0.53	2.89		1	0.43	0.57	0.54	0.48
ISE03	7.41	1.65	–1.21	4.40			1	0.65	0.53	0.42
ISE04	7.09	1.67	–0.96	4.09				1	0.65	0.47
ISE05	6.85	1.71	–0.96	3.83					1	0.46
ISE06	6.95	1.73	–0.91	3.86						1

Note. Responses ranged from 1 (*Strongly Disagree*) to 9 (*Strongly Agree*).

Table 7. Descriptive Statistics and Inter-Item Correlations for Emotion Regulation Items

Item #	*M*	*SD*	Skew	Kurtosis	ER01	ER02	ER03	ER04	ER05	ER06
ER01	5.99	1.92	–0.34	–0.38	1	0.52	0.21	0.21	0.34	0.24
ER02	5.50	1.92	–0.07	–0.56		1	0.24	0.01	0.50	0.16
ER03	4.94	1.97	0.09	–0.71			1	0.41	0.13	0.43
ER04	4.17	2.17	–0.39	–0.72				1	0.01	0.60
ER05	6.33	1.80	–0.54	–0.08					1	0.12
ER06	4.31	2.18	–0.23	–0.93						1

Note. Responses ranged from 1 (*Strongly Disagree*) to 9 (*Strongly Agree*).

Table 8. Descriptive Statistics and Inter-Item Correlations for Perspective-Taking Items

Item #	*M*	*SD*	Skew	Kurtosis	PT01	PT02	PT03	PT04	PT05	PT06	PT07
PT01	6.10	2.03	–0.48	2.32	1	0.26	0.31	0.33	0.23	0.20	0.26
PT02	6.84	1.67	–0.56	2.92		1	0.57	0.15	0.53	0.51	0.49
PT03	6.92	1.70	–0.78	3.48			1	0.25	0.57	0.57	0.62
PT04	5.59	2.12	–0.34	2.47				1	0.19	0.14	0.16
PT05	7.02	1.67	–0.70	3.14					1	0.42	0.53
PT06	5.93	2.02	–0.36	2.39						1	0.73
PT07	6.17	1.97	–0.43	2.69							1

Note. Responses ranged from 1 (*Strongly Disagree*) to 9 (*Strongly Agree*).

Table 9. Descriptive Statistics and Inter-Item Correlations for Empathic Concern Items

Item #	*M*	*SD*	Skew	Kurtosis	EC01	EC02	EC03	EC04	EC05	EC06	EC07
EC01	7.00	2.05	–1.00	3.41	1	0.33	0.48	0.47	0.39	0.62	0.63
EC02	6.19	2.21	–0.58	2.54		1	0.16	0.57	0.41	0.22	0.34
EC03	7.14	1.78	–1.26	4.82			1	0.28	0.34	0.54	0.47
EC04	6.08	2.21	–0.60	2.47				1	0.64	0.29	0.37
EC05	7.10	2.02	–1.38	4.44					1	0.30	0.30
EC06	6.69	1.89	–0.96	3.66						1	0.62
EC07	6.43	2.06	–0.51	2.41							1

Note. Responses ranged from 1 (*Strongly Disagree*) to 9 (*Strongly Agree*).

dual Empathic Concern (EC) survey items. The most positive responses were to EC03 (M = 7.14, SD = 1.78) and the least positive responses were to EC04 (M = 6.08, SD = 2.21). All items showed standard deviations between 1.78 and 2.21. All survey items were moderately skewed to the left, with three items exhibiting skewness values greater than 1.0 in magnitude (i.e., EC01, EC03, EC05). Most inter-item correlations were greater than 0.30, although EC03 exhibited two correlations with other EC items that were not.

4.2 Confirmatory factor analysis

4.2.1 Interpersonal self-efficacy

The CFA model estimating the latent variable, Interpersonal Self-efficacy, was initially estimated with each error term isolated. While this model fit was acceptable, χ^2 (9) = 15.34, p = 0.08, RMSEA = 0.058, 90% CI [0.000, 0.107], TLI = 0.98, the RMSEA was very close to the suggested cutoff for a "very good" model of 0.06 [31]. Therefore, we reexamined each item and sought to develop a stronger model. In the revision, the error terms associated with ISE02, "I consider another person's perspective before making a decision," and ISE06, "Before finalizing a decision, I like to gather feedback from others," were modelled as correlated.

The revised and final nonstandard CFA model estimating the latent variable, Interpersonal Self-Efficacy, fit the measured data well and was superior to the prior model, χ^2 (8) = 10.58, p = 0.227, RMSEA = 0.039, 90% CI [0.000, 0.096], TLI = 0.991. Standardized factor loadings ranged from 0.56 to 0.75. The minimum possible sum of results was 4.34 (assuming a response of 1 to each item) and

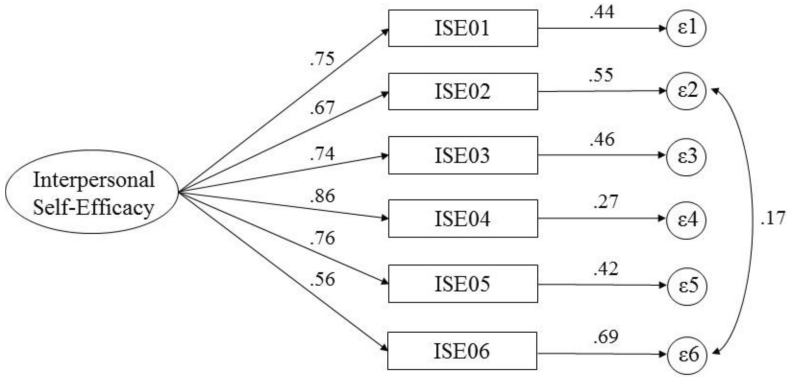

Fig. 1. Measurement model the Interpersonal Self-Efficacy (ISE) construct.

the maximum possible response was 39.06 (assuming a response of 9 to each item). Fig. 1 provides a graphical depiction of the measurement model.

4.2.2 Emotion regulation

The CFA model estimating the latent variable, Emotion Regulation, was initially estimated using all six items listed in Table 3. The model fit was unacceptable, χ^2 (9) = 141.99, $p < 0.01$, RMSEA = 0.267, 90% CI [0.229, 0.307], TLI = 0.232. Hence, we removed items with the smallest factor loading stepwise until the model fit the specified objectives. Through this process, two items were removed. First, ER04, "I tend to lose control when I cannot find the right answer to a problem," with an initial factor loading of 0.28, was removed. Second, ER06, "I tend to lose control when faced with several competing issues at once," which exhibited a factor loading of 0.28 in the subsequent model (that was still unacceptable) was removed. These items were adapted from Davis's Personal Distress scale [13]. Notably, both of these items were negatively worded. Furthermore, upon review, each of these items contained strong, negative verb usage referencing "losing control." Our team's hypothesis is that this strong, negative word usage may have elicited a negative reaction among respondents, as acts such as "losing control" may not be socially acceptable for the generation of students that we surveyed (we revisit this consideration in the discussion).

The revised and final nonstandard CFA model estimating the latent variable, Emotion Regulation, fit the measured data well and was superior to the prior models, χ^2 (2) = 0.87, $p = 0.647$, RMSEA < 0.001, 90% CI [0.000, 0.108], TLI = 1.025. Standardized factor loadings ranged from 0.28 to 0.87. The minimum possible response to the construct was 2.33 and the maximum possible response was 20.97. Fig. 2 provides a visualization of the measurement model.

4.2.3 Perspective-taking

We anticipated that adjustments to the Perspective-Taking construct would be unnecessary. However, the CFA model estimating the seven-item construct was unacceptable, χ^2 (14) = 57.09, $p < 0.01$, RMSEA = 0.122, 90% CI [0.090, 0.156], TLI = 0.874. Therefore, we made two changes to the model. First, items were reviewed and analyzed to ascertain which two items, if any, were most similar and potentially had shared variance. Items PT06, "When I'm upset at someone, I usually try to 'put myself in his shoes' for a while," and PT07, "Before criticizing somebody, I try to imagine how I would feel if I were in their place," were judged to be most alike. Hence, the error terms for these items were modelled as correlated. This change improved the model, but the model still did not meet the specified objectives. Therefore, we removed PT04, "If I'm sure I'm right about something, I don't waste much time listening to other people's arguments," as it showed the smallest factor loading (0.277). Further, upon a review of the PT construct's inter-item correlations, this item exhibited weak correlations (i.e., $r < 0.30$) with almost every other item on the construct. Lastly, as we reviewed PT04, this item's emphasis appeared to be more akin to the skill or tendency to *listen* than the act of imagining the internal processes of another's mind or body.

The revised and final nonstandard CFA model estimating the latent variable, Perspective-Taking, fit the measured data well and was superior to the prior models, χ^2 (8) = 9,13, $p = 0.332$, RMSEA = 0.026, 90% CI [0.000, 0.088], TLI = 0.996. Standardized pattern coefficients ranged from 0.32 to 0.87. The minimum possible response to the construct was 3.20 and the maximum was 28.80. The measurement model is shown in Fig. 3.

4.2.4 Empathic concern

As above, we anticipated that adjustments to the Empathic Concern construct would be unnecessary. However, the CFA model estimating the seven-item construct was unacceptable with the student population, χ^2 (14) = 136.93, $p < 0.01$, RMSEA = 0.206, 90% CI [0.175, 0.238], TLI = 0.673. Therefore, we removed items step-wise, excluding the item that showed the smallest factor loading and then re-testing the model until the model fit was acceptable.

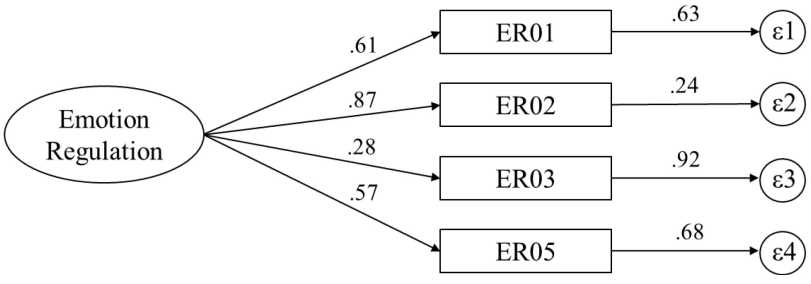

Fig. 2. Measurement model the Emotion Regulation (ER) construct.

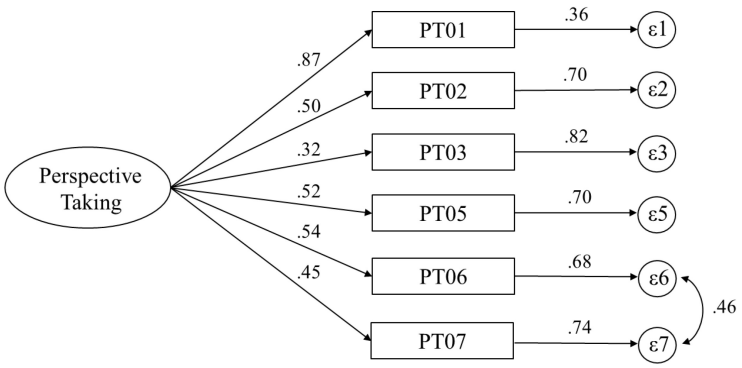

Fig. 3. Measurement model the Perspective-Taking construct.

Through this process, three items were removed: (a) EC02, "Sometimes I don't feel very sorry for other people when they are having problems;" (b) EC04, "Other people's misfortunes do not usually disturb me a great deal," and (c) EC05, "When I see someone being treated unfairly, I sometimes don't feel very much pity for them." Upon review, each of these items appeared unnecessarily wordy. These items may have also elicited negative reactions among respondents (we elaborate on this possibility in the discussion).

The revised and final nonstandard CFA model estimating the latent variable, Empathic Concern, fit the measured data, χ^2 (2) = 2.08, p = 0.354, RMSEA = 0.014, 90% CI [0.000, 0.139], TLI = 0.999. Standardized pattern coefficients ranged from 0.63 to 0.81. The minimum possible response to the construct was 3.01 and the maximum was 27.09. Fig. 4 provides a graphical depiction of the measurement model.

4.3 Correlation analysis

Lastly we assessed construct validity [34] by evaluating the relationship between the newly designed constructs and those from the IRI [13]. Specifically, we examined the bivariate correlations among Interpersonal Self-Efficacy and Emotion Regulation with two empathy variables: Perspective-Taking and Empathic Concern. Table 10 provides a summary of these results. Note that each individual construct was computed by multiplying each individual response item by the appropriate factor loading and then summing these item scores. Next, all items were standardized by multiplying this score by 9 (the maximum response on the original Likert-type scale) and then dividing by the maximum points possible (as stated above).

All items exhibited a significant correlation at a 99% confidence level ($p < 0.01$). The effect sizes of the correlations were large (i.e., $r > 0.50$) for ISE/EC

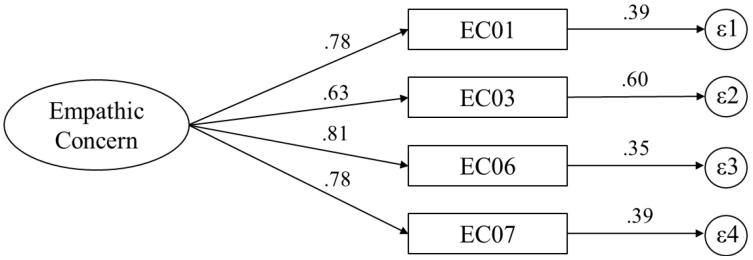

Fig. 4. Measurement model for the Empathic Concern construct.

Table 10. Descriptive Statistics for and Correlations between Survey Constructs

Construct	M	SD	ISE	ER	PT	EC
Interpersonal Self-Efficacy (ISE)	6.93	1.32	1	0.48**	0.68**	0.73**
Emotion Regulation (ER)	5.76	1.42		1	0.38**	0.21**
Perspective-Taking (PT)	6.43	1.34			1	0.59**
Empathic Concern (EC)	6.80	1.61				1

N = 207; **$p < 0.01$ (two-tailed).

Note: Individual scores were computed by multiplying each individual item by the appropriate factor loading and summarizing items, and then standardized by dividing individual scores by the maximum points possible on the construct and then multiplying that score by 9 (the highest response possible on the original Likert-type scale).

($r = 0.73$), ISE/PT ($r = 0.68$), and PT/EC ($r = 0.59$); medium (i.e., $r > 0.30$) for ISE/ER ($r = 0.48$) and PT/ER ($r = 0.38$); and small (i.e., $r > 0.10$) for EC/ER ($r = 0.21$). Note that these thresholds were taken from Cohen [29].

5. Discussion

This study tested the theory that the phenomena, interpersonal self-efficacy and emotion regulation, could be measured in a valid manner. An operational definition of each phenomena was established by synthesizing select literature on interpersonal self-efficacy or interpersonal competence [i.e., 19, 21] and emotion regulation [i.e., 10, 23]. Survey items were then designed by synthesizing related prior instrumentation [i.e., 13, 21, 32] and considering item alignment with the extant literature. The theoretical components underlying the phenomena were specified, survey items were adapted or designed, and the survey items were qualitatively checked to ensure that those core components were encapsulated by the items. We then established the theoretical relation between Interpersonal Self-Efficacy, Emotion Regulation, Perspective-Taking, and Empathic Concern by considering this literature in relation to scholarship on empathy [i.e., 10, 13, 25]. Finally, we tested the inter-relation between these phenomena through correlation analyses.

This discussion articulates why the structural changes that were made were necessary; how the constructs' componential structures can help explain the correlation findings; and the potential study limitations. We conclude the study with a summation of findings and a consideration of this study's utility for other educators.

5.1 Structural considerations

The structural validity of four constructs was analyzed using confirmatory factor analytic procedures. When models were unacceptable, we began scrutinizing questions and re-modelling the constructs as needed, either by adding correlations between error terms for like-items or altogether removing items to seek model fit. For each of the survey constructs, we were able to attain a structurally robust solution. However, each model required modification from the initial, prescribed solution. This change was minimal for Interpersonal Self-Efficacy, where the theorized factor structure was bolstered by modelling two error terms as correlated. This was the only construct that did not require the removal of items.

The Emotion Regulation construct required the removal of two items. These items were largely derived from Davis's Personal Distress scale [13]. Upon review, each of these items contained strong, negative verb usage referencing "losing control." Our team's hypothesis is that this strong, negative word usage may have elicited negative responses from many students. We theorize that this may be an especially impactful factor in instrument design today as there is a national emphasis on acceptance and diversity [35], especially in the STEM university context [1, 36, 37]. In other words, the contemporary university milieu advocates understanding and sensitivity (which are arguably related to but not synonymous with empathy, see Davis for a discussion on these considerations [38, pp. 85–88]), and these overarching institutional norms may factor into individual student responses (subconsciously or consciously).

We originally did not intend to modify or remove items from the Interpersonal Reactivity Index constructs. However, following a CFA of Perspective-Taking, we decided to modify the construct due to lack of model fit. Specifically, we removed PT04, "If I'm sure I'm right about something, I don't waste much time listening to other people's arguments," and received an acceptable model fit. Upon review, we noted that this item's emphasis was closer to the skill or tendency to listen than the act of imagining or seeking to internalize the state of another's mind. While we did not extrapolate Perspective-Taking's core components a priori, this emphasis on "imagining how another is thinking or feeling" [9], as opposed to listening to the other or even imagining the self-as-other [see 39, 40], is core to the phenomena. This imagine-other component was missing in the instance of PT04. While the IRI has been used in prior engineering education studies (i.e., in service-learning [15], design [16], and ethics [17]), this finding suggests that future uses of the IRI might incorporate this change (pending other researchers own validation checks).

In validating the Empathic Concern construct, we removed three questions. Upon review, we felt that each question was excessively wordy. Further, these questions may have also elicited negative reactions among respondents, given their potentially socially repugnant insinuations, such as, "I don't feel very sorry," or "I don't feel very much pity . . ." These concerns align with the discussion of the Emotion Regulation changes (see above). As with Perspective-Taking, instructors using the IRI to ascertain changes in students' empathic development ought check the validity of the instrumentation with their sample and, as needed, adjust their measurement procedures.

Most of the questions that were removed were reverse worded, meaning we had to reverse item scores before generating descriptive statistics or performing factor analytic procedures. Hence, we

were concerned that the validity of this analysis may have been influenced by respondents who may have simply clicked through the survey, which is one of the unfortunate risks of self-report testing. However, we note that PT01, ''I sometimes find it difficult to see things from the 'other guy's' point of view,'' was not removed. Rather, it had the strongest impact on the Perspective-Taking construct following the CFA.

5.2 *Relationship between constructs*

After performing CFA, individual scores on survey constructs were computed and the hypothesized relationship between each construct was tested. The componential structure underlying the constructs guided our explanation of these correlations. Interpersonal Self-Efficacy included four primary components: (a) Awareness of self; (b) Awareness of other; (c) Relation between self and other; and (d) Commitment to diversity of thought. Likewise, Emotion Regulation included four core components: (a) Awareness of self; (b) Comfort with complexity; (c) Acceptance of uncertainty; and (d) Ability to cope with stress. We did not derive the componential structure of Perspective-Taking and Empathic Concern a priori. Nonetheless, in this section we map and discuss which components are aligned with which constructs. Table 11 provides a map depicting the alignment of components to constructs, and the discussion further unpacks this mapping.

The highest correlations we found were between Interpersonal Self-Efficacy and Empathic Concern ($r = 0.73$) followed by Interpersonal Self-Efficacy and Perspective-Taking ($r = 0.68$). These high correlations are supported by the extant literature on empathy that suggests its positive role in prosocial interpersonal behavior [25] and functional operation in interpersonal situations [13, 38]. As we revisit the empathy constructs, their underlying components appear directly aligned with Interpersonal Self-Efficacy. Specifically, three of the four components are foundational to each construct: (a) Awareness of self; (b) Awareness of other; and (c) Relation between self and other. The fourth Interpersonal Self-Efficacy component, commitment to diversity of thought, is the defining distinction between this phenomenon and the empathy constructs.

While Emotion Regulation exhibited positive and significant correlations with Perspective-Taking ($r = 0.38$) and Empathic Concern ($r = 0.21$), these correlations were much weaker than those between Interpersonal Self-Efficacy and the empathy constructs. As we reviewed the construct, we noted that it contained less emphasis on people and a greater emphasis on a reflection of one's self as s/he interacts with a complex problem. This is especially evident when comparing its four core components with Interpersonal Self-Efficacy. While both include ''Awareness of self'' a core component, Interpersonal Self-Efficacy included ''Awareness of other'' and ''Relation between self and other'' while Emotion Regulation did not.

With that said, Emotion Regulation's conceptual foci regarding ''complexity,'' ''uncertainty,'' and ''coping with stress'' might also elicit self-reflections that consider the self/other encounter or relationality, dependent on how one perceives or imagines select terms that are embedded in the items (i.e., ''complexity'', ''problems''). In everyday life, much of the complexity and uncertainty one encounters, and the need to cope with the stress induced therefrom, is caused by the ''others'' with whom we find ourselves intimately relating. This is perhaps a reason why, despite the weaker correlations, the statistical significance persists.

Finally, as we revisit the theory underlying emotion regulation vis-à-vis empathy, these weaker correlations may become less concerning. In terms of empathy, the notion is that in order to empathize with another, one must have the regulatory capacity to avoid becoming over-stressed [10]. If one internalizes too much stress, their attention will generally turn inwards, thereby inhibiting their empathic potential. Therefore, to effectively respond to complex and ''wicked'' engineering and scientific problems, which by definition include numerous stakeholders and competing solutions [41], one must have an orientation for engaging with the

Table 11. Alignment of Constructs' Componential Structures

Component	Interpersonal Self-Efficacy	Emotion Regulation	Perspective-Taking	Empathic Concern
Awareness of self	X	X	X	X
Awareness of other	X	*	X	X
Relation between self and other	X	*	X	X
Commitment to diversity of thought	X			
Comfort with complexity		X		
Acceptance of uncertainty		X		
Ability to cope with stress		X		

* Indicates that there is potentially an indirect connection via other components.

thoughts and values of those diverse stakeholders before finalizing any solution. However, as described in the framework offered by Hoffman [25], emotion regulation skills provide greater *empathic potential*, but they do not ensure Perspective-Taking or Empathic Concern. Hence, we would theorize that individuals *lacking* emotion regulation skills would be *less* prone to empathize in stressful environments than individuals with greater emotion regulation skills.

5.3 Limitations

First, subjects in this study were undergraduate students from a single university. Hence, it may be the case that the factor solution may not hold for students at other sites. Future studies ought to perform similar factor analytic procedures and compare those findings with these.

Second, we recognize the potential limitations of self-report survey design when compared to other instrumentation, such as the Implicit Association Test (IAT), as the former, though useful, may be inaccurate when topics are socially sensitive [42]. This is not to suggest that implicit testing procedures, including the IAT, are without limitations [i.e., how to properly attribute the mechanisms underlying latency, see 43]. Nonetheless, as Greenwald et al. (2009) argue, the IAT theoretically minimizes biased results by requiring rapid response, whereas in self-report instruments the respondent has time to reflect on questions and consider a myriad of factors (i.e., individual, political, social) before responding. Today, self-report continues to be an accepted and common strategy for evaluating courses and curriculum [19].

Lastly, quantitative findings alone may be insufficient to attribute causality. Our team recognizes that often it is important to adopt a mixed methods way of thinking, wherein the researcher seeks to leverage and engage a multiplicity of lenses, values, and research methods to generate a comprehensive picture of reality [44]. We envision that this validation study can serve as one tool for future researchers to utilize as they seek similar learning outcomes among their own student populations.

6. Conclusion

In this study, survey constructs designed to gauge science and engineering students' tendencies to apply four interpersonal skills were described, their structural validity was ascertained, and the constructs' inter-relationships were analyzed. Through confirmatory factor analytic procedures, structurally robust models of each construct were identified. In each instance, we needed to modify the constructs as originally designed to identify a structurally valid model. Correlation analyses revealed significant inter-construct relationships. While Emotion Regulation exhibited significant inter-construct relationships with the other survey constructs, these were noticeably less than Interpersonal Self-Efficacy. In general, these findings can facilitate future explorations on engineering and science students' professional formation. For example, future studies may use these constructs to (1) compare student responses across engineering, science, and other disciplines; (2) develop a comprehensive model of engineering students' professional development; or (3) identify changes in students' professional development resulting from engineering and science curriculum.

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References

1. National Academy of Engineering, *The Engineer of 2020: Visions of engineering in the new century*, National Academies Press, Washington DC, 2004.
2. Joint Task Force on Undergraduate Physics Programs, *Phys21: Preparing physics students for 21st-century careers*, American Physical Society, College Park, MD, 2016.
3. M. C. Loui, Ethics and the development of professional identities of engineering students, *Journal of Engineering Education*, **94**(4), 2005, pp. 383–390.
4. A. Beatty, *Service-learning in undergraduate geosciences*, The National Academies Press, Washington, DC, 2017.
5. ABET. (n.d., Criteria for accrediting engineering programs, 2016-2017. Available: http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2016-2017/
6. M. L. Casado, D. Lopez-Fernandez and V. Lapuerta, Socio-emotional competencies in engineering education, *International Journal of Engineering Education*, **32**(4), 2016, pp. 1660–1678.
7. 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*, **106**(1), 2017, pp. 123–148.
8. J. L. Hess, N. D. Fila and S. Purzer, The relationship between empathic and innovative tendencies among engineering students, *International Journal of Engineering Education*, **32**(3A), 2016, pp. 1236–1249.
9. C. D. Batson, These things called empathy: Eight related but distinct phenomenon, in J. Decety and W. Ickes (eds), *The Social Neuroscience of Empathy*, MIT Press, Cambridge, MA, 2009, pp. 3–15.
10. J. Decety and Y. Moriguchi, The empathic brain and its dysfunction in psychiatric populations: Implications for intervention across different clinical conditions, *BioPsychoSocial Medicine*, **1**, 2007, pp. 1–22.
11. O. Pierrakos, Changing the culture in a senior design course to focus on grit, mastery orientation, belonging, and self-efficacy: Building strong academic mindsets and pschological preparedness, *International Journal of Engineering Education*, **33**(5), 2017, pp. 1453–1467.
12. E. J. Lawrence, P. Shaw, D. Baker, S. Baron-Cohen and A. S. David, Measuring empathy: Reliability and validity of the Empathy Quotient, *Psychological Medicine*, **34**(5), 2004, pp. 911–920.
13. M. H. Davis, Measuring individual differences in empathy:

Evidence for a multidimensional approach, *Journal of Personality and Social Psychology*, **44**(1), 1983, pp. 113–126.
14. C. K. Y. Chan, Y. Zhao and L. Y. Y. Luk, A validated and reliable instrument investigating engineering students' perceptions of competency in generic skills, *Journal of Engineering Education*, **106**(2), 2017, pp. 299–325.
15. L. Wang, T. K. Caroll and D. A. Delaine, A pilot study of the development of empathy within a service-learning trip from a qualitative perspective, *ASEE Annual Conference & Exposition*, Salt Lake City, UT, 2018.
16. A. O. Surma-aho, T. A. Bjorklund and K. Holtta-Otto, Assessing the development of empathy and innovation attitudes in a project-based engineering design course, *ASEE Annual Conference & Exposition*, Salt Lake City, UT, 2018.
17. J. L. Hess, *A multi-phase exploration of conceptualizations, perceived importance, and the development of empathy within engineering*, PhD, Purdue University, West Lafayette, IN, 2015.
18. G. A. Fore, J. L. Hess, B. Sorge, M. F. Price, M. A. Colean, T. W. Hahn, et al., An introduction to the Integrated Community-Engaged Learning and Ethical Reflection Framework (I-CELER), *American Society for Engineering Education*, Salt Lake City, UT, 2018.
19. National Research Council, *Education for life and work: Developing transferable knowledge and skills in the 21st century*, National Academies Press, Washington, DC, 2012.
20. J. Herman and M. Hilton, Eds., *Supporting students' college success: The role of assessment of intrapersonal and interpersonal competencies*. Washington, DC: The National Academies Press, 2017.
21. C. R. Seal, K. Miguel, A. Alzamil, S. E. Naumann, J. Royce-Davis and D. Drost, Personal-interpersonal competence assessment: A self-report instrument for student development, *Research in Higher Education*, **27**, 2015.
22. P. N. Lopes, J. M. Mestre, R. Guil, J. P. Kremenitzer and P. Salovey, The role of knowledge and skills for managing emotions in adaptation to school: Social behavior and misconduct in the classroom, *American Educational Research Journal*, **49**(4), 2012, pp. 710–742.
23. N. Eisenberg and T. L. Spinrad, Emotion-related regulation: Sharpening the definition, *Child Development*, **75**(2), 2004, pp. 334–339.
24. N. Eisenberg, R. A. Fabes, M. Schaller and P. A. Miller, Sympathy and personal distress: Development, gender differences, and interrelations of indexes, *New Directions for Child and Adolescent Development*, **44**, 1989, pp. 107–126.
25. M. L. Hoffman, *Empathy and moral development: Implications for caring and justice*, Cambridge University Press, Cambridge, UK, 2000.
26. K. S. Steinberg, J. A. Hatcher and R. G. Bringle, Civic-minded graduate: A north star, *Michigan Journal of Community Service Learning*, **18**(1), 2011, pp. 19–34.
27. J. R. Rest, D. Narvaez, S. J. Thoma and M. J. Bebaue, DIT2: Devising and testing a revised instrument of moral judgment, *Journal of Educational Psychology*, **91**(4), 1999, pp. 644–659.
28. R. B. Kline, *Principles and practice of structural equation modeling*, 4th ed., The Guilford Press, New York, 2016.
29. J. Cohen, A power primer, *Quantitative Methods in Psychology*, **112**(1), 1992, pp. 155–159.
30. B. G. Tabachnick and L. S. Fidell, *Using multivariate statistics*, 6th ed., Pearson, Harlow, 2014.
31. L. Hu and P. M. Bentler, Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification, *Psychological Methods*, **3**(424–453), 1998.
32. G. L. Downey, J. C. Lucena, B. M. Moskal, R. Parkhurst, T. Bigley, C. Hays*, et al.*, The globally competent engineer: Working effectively with people who define problems differently, *Journal of Engineering Education*, **95**(2), 2006, pp. 107–122.
33. J. L. Hess and N. D. Fila, The development and growth of empathy among engineering students, *American Society for Engineering Education Annual Conference*, New Orleans, LA, 2016.
34. S. Messick, Validity of psychological assessment: Validation of inferences from persons' responses and performances as scientific inquiry into score meaning, *American Psychologist*, **50**(9), 1995, pp. 741–749.
35. United Nations General Assembly, "Transforming our world: The 2030 Agenda for Sustainable Development," 2015.
36. National Academy of Sciences, National Academy of Engineering, Policy and Global Affairs, and Institute of Medicine, Eds., *Expanding underrepresented minority participation: America's science and technology talent at the crossroads*. Washington, DC: The National Academies Press, 2011.
37. S. M. Malcolm and M. Feder, Eds., *Barriers and opportunities for 2-Year and 4-Year STEM degrees: Systemic change to support students' diverse pathways*. Washington, DC: The National Academies Press, 2016.
38. M. H. Davis, *Empathy: A social psychological approach*, Westview Press, Boulder, CO, 1996.
39. E. Stotland, Exploratory investigations on empathy, *Advances in Experimental Social Psychology*, **4**, 1969, pp. 271–314.
40. C. D. Batson, S. Early and G. Salvarani, Perspective taking: Imagining how another feels versus imagining how you would feel., *Personality and Social Psychology Bulletin*, **23**(7), 1997, pp. 751–758.
41. H. W. J. Rittel and M. M. Webber, Dilemmas in a general theory of planning, *Policy Sciences*, **4**(2), 1973, pp. 155–169.
42. A. G. Greenwald, B. A. Nosek and M. R. Banaji, Understanding and using the Implicit Association Test: III. Meta-analysis of predictive validity, *Journal of Personality and Social Psychology*, **97**(1), 2009, pp. 17–41.
43. C. E. Goodall, An overview of implicit measures of attitudes: Methods, mechanisms, strengths, and limitations, *Communication Methods & Measures*, **5**(3), 2011, pp. 203–222.
44. J. C. Greene, *Mixed methods in social inquiry*, Jossey-Bass, San Francisco, CA, 2007.
45. J. L. Hess, S. A. Brownell, R. A. House, and A. T. Dale, *Development and application of the Sustainability Skills and Dispositions Scale to the Wicked Problems in Sustainability Initiative*, Presented at the ASEE Annual Conference & Expositions, Seattle, WA, 2015.

Appendix A: Emotion Regulation and Interpersonal Self-Efficacy Survey Items

The following statements inquire about your thoughts and feelings in a variety of situations. Please indicate the extent to which you agree or disagree with this statement by checking the appropriate number. Please respond from 1 to 9 where 1 = "Strongly Disagree" and 9 = "Strongly Agree".

1. I feel prepared to work with people who define a problem differently than I do.
2. When I cannot find the right solution to a problem, I tend to remain calm.
3. When dealing with complexity, I feel at-ease.
4. I consider another person's perspective before making a decision.
5. When I think about all of the individuals who need help, I go to pieces.
6. I sometimes feel helpless when I am working on a very complex issue.
7. I am prepared to meet and work with individuals from different backgrounds.

8. I value opinions that are different from my own.
9. I tend to lose control when I cannot find the right answer to a problem. (removed)
10. Really, there is nothing I can do about the problems of the world.
11. I don't shy away from complicated problems.
12. I am generally able to understand the viewpoints of others.
13. I tend to lose control when faced with several competing issues at once. (removed)
14. Before finalizing a decision, I like to gather feedback from others.

Appendix B: Interpersonal Reactivity Index Items

The following statements inquire about your thoughts and feelings in a variety of situations. Please indicate the extent to which you agree or disagree with this statement by checking the appropriate number. Please respond from 1 to 9 where 1 = "Strongly Disagree" and 9 = "Strongly Agree".

1. I often have tender, concerned feelings for people less fortunate than me.
2. I sometimes find it difficult to see things from the "other guy's" point of view.
3. Sometimes I don't feel very sorry for other people when they are having problems.
4. I try to look at everybody's side of a disagreement before I make a decision.
5. When I see someone being taken advantage of, I feel kind of protective towards them.
6. I sometimes try to understand my friends better by imagining how things look from their perspective.
7. Other people's misfortunes do not usually disturb me a great deal.
8. If I'm sure I'm right about something, I don't waste much time listening to other people's arguments.
9. When I see someone being treated unfairly, I sometimes don't feel very much pity for them.
10. I am often quite touched by things that I see happen.
11. I believe that there are two sides to every question and try to look at them both.
12. I would describe myself as a pretty soft-hearted person.
13. When I'm upset at someone, I usually try to "put myself in his shoes" for a while.
14. Before criticizing somebody, I try to imagine how I would feel if I were in their place.

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