The Relationship Between Empathy and Civic-Mindedness in First-Year Engineering Students

Athena Lin
School of Engineering Education
Purdue University
West Lafayette, IN
aln@purdue.edu

Justin L. Hess
School of Engineering Education
Purdue University
West Lafayette, IN
jhess@purdue.edu

Arístides P. Carrillo Fernández
School of Engineering Education
Purdue University
West Lafayette, IN
carril11@purdue.edu

***Abstract*— This Research Full Paper explores the relationship between civic-mindedness and empathy, both of which are instrumental to helping engineers meaningfully engage with community members and their needs. This study addresses the research question: "What aspects of civic-mindedness are significant predictors of empathy in first-year engineering students?" We administered a survey to first-year engineering students in Fall 2019 that included the Civic-Minded Graduate Scale (as a measure of civic-mindedness) and the Interpersonal Reactivity Index (as a measure of empathic concern and perspective taking). We administered the survey once at the start of the course and again at the end of the course to measure changes in civic-mindedness and empathy across the semester. We used 366 complete survey responses to generate regression models predicting students' empathic concern and perspective taking tendencies based on five civic-mindedness factors. Results indicated that, when adjusting for students' civic-mindedness at the start of the semester, select aspects of civic-mindedness inform students' general empathic tendencies. These findings suggest that teaching civic-mindedness to engineering students can also enhance their empathic skills and dispositions.**

Keywords—civics; civic-mindedness; empathy; regression

I. Introduction

This study explores the relationship between the dispositions of civic-mindedness and empathy. Civic-mindedness refers to one's willingness to act on feelings of obligation to serve a community. Civic-mindedness is an important disposition for engineers as it enables them to effectively harness their professional skills to improve the livelihoods of communities [1]. Empathy is also instrumental to effective community development efforts [2]. Thus, understanding how the dispositions of civic-mindedness and empathy interrelate can help educators prepare students to serve their communities more effectively.

While a concerted focus on civics in engineering education is limited, recent years in engineering education have seen a rapid rise in scholarship on empathy in engineering. As this work draws attention to, there is a potential connection between empathy and community-engagement [2], considering societal needs on a macro-level [3], and considering how one may be of service to society [4]. In this study, we extend this recent work by quantitatively exploring the relationship between civic-mindedness and empathy within the context of engineering education. We address the following research questions:

1. To what extent does civic-mindedness predict empathy in first-year engineering students?
2. What aspects of civic-mindedness are significant predictors of empathy in first-year engineering students?

II. Literature Review

A. Civic-Mindedness

1) How can we promote civic learning?

Over 70 years ago, The President's Commission on Higher Education [5] wrote, "The first and most essential charge upon higher education is that at all levels and in all its fields of specialization it shall be the carrier of democratic values, ideals, and processes" (p. 102). Nearly 50 years later, Boyer [6] (who was the President of the Carnegie Foundation for the Advancement of Teaching at the time) asked, "Is it possible for the work of the academy to relate more effectively to our most pressing social, economic, and civic problems?" A few years later, building on Dewey's foundational work in *Democracy and Education*, Colby and Ehrlich [7] suggested that "our society requires civic engagement to realize the potential of its citizens and communities." Thus, like many before them, Colby and Ehrlich [7] called for a more concerted focus on civic learning in higher education.

Despite these calls for civic learning across multiple decades, post-secondary instruction for professions tends to teach content in isolation of these civic-oriented issues [7]. As a result, we see disconcerting findings such as in Cech's [8] study, which found that engineering programs tend to generate reduced concerns for public welfare among students. Separately, Morgan, et al. [9] found that engineering students experienced politics "at the periphery of engineering" as well as "limited exposure to politically motivating events" (p. 107). These findings support the critical need to foster greater integration of civic pedagogies within and across engineering programs.

To clarify dispositional changes resulting from civic pedagogies, Bringle and Steinberg [10] offered the specific framing of *civic-mindedness*, which they defined as one's "inclination or disposition to be knowledgeable of and involved in the community, and to have a commitment to act upon a sense of responsibility as a member of that community" (p. 429). Steinberg et al. [1] expanded this work and offered a tripartite model of civic-mindedness that conceptualizes civic-mindedness as constituting (1) awareness of one's identity which interrelates with and is a product of select (2) educational

experiences and (3) civic experiences. Herein, they defined civic experiences as "ways in which a person is actively involved in the community." They provided multiple examples of civic experiences that can promote civic-mindedness, such as "advocacy work, community service, leadership, civic organization participation, political involvement, volunteering, and voting." We draw on the Civic-Minded Graduate Scale designed by Steinberg et al. [1] in this study, and we provide more details on this measure below.

2) How have engineering educators promoted civic learning?

Engineering educators have incorporated civic learning through different pedagogies. For example, Bielefeldt and Lima [11] explicitly discussed the potential outcomes of service-learning design-based pedagogies on engineering students' sense of civic responsibility. Similarly, Kahl [12] offered a combinatorial approach of "engineering design and community engagement" to promote learning goals pertaining to sustainability, interdisciplinary collaboration, and leadership. Huffman and Roche [13] used community-oriented critical reflection activities to foster architectural technology students' sense of civic identity and civic-mindedness. Williams [14] offered instruction in technical communication as way to foster civic responsibility.

These studies highlight the variation in ways that scholars have explicitly introduced civic learning to engineering students. These examples also suggest that civic learning may manifest in engineering students' learning even when not explicitly called forth. For example, related pedagogies we have mentioned thus far include service learning, design, politics, identity, and communication. These are but a few potential extant examples of how civics may already manifest in engineering education. Another related phenomenon is social responsibility, which we see as similar to but slightly distinct from civic responsibility [15].

3) How can we measure civic-mindedness?

The Civic-Minded Graduate Scale (CMG Scale, [1]) was designed to measure civic outcomes that exemplify the qualities of a "civic-minded graduate," or a college graduate with the "capacity and desire to work with others to achieve the common good" (p. 20). In this framework, civic-mindedness is defined as "a person's inclination or disposition to be knowledgeable of and involved in the community, and to have a commitment to act upon a sense of responsibility as a member of that community" (p. 20). In other words, this definition of civic-mindedness encompasses civic knowledge, dispositions, and skills [10].

Prior studies have indicated that the 30 items in the Civic-Minded Graduate Scale reduce to a unidimensional measure of civic-mindedness [1]. Like other instruments measuring civic attitudes, the Civic-Minded Graduate Scale includes subscales to capture different aspects of civic-mindedness [16]. Hess et al. [17] used Exploratory Factor Analysis and Confirmatory Factor Analysis with engineering students. They found that the thirty items on the Civic-Minded Graduate Scale reduced to five underlying constructs of civic-mindedness: (1) Valuing community engagement, (2) Confidence in influencing social issues[1], (3) Civic knowledge and skills, (4) Empathic interpersonal community, and (5) Civic intentions and obligations. As these constructs were developed based on a sample of engineering students, we use this modified five-factor structure in this study.

[1] The study by Hess et al. [17] named Factor 2 "Confidence in building consensus". We have since renamed Factor 2 as "Confidence in influencing social issues", which more accurately represents the four items. The items in Factor 2 remain the same.

B. Empathy

1) What is empathy?

Empathy colloquially refers to putting oneself in someone else's shoes. However, empathy is a complex and multidimensional phenomenon. Batson [18] argued that scholars had studied eight distinct but related empathy types, which Hess and Fila [19] paraphrased as: 1) Empathy accuracy, 2) Motor mimicry, 3) Emotional contagion, 4) Projection, 5) Perspective taking (imagine-other), 6) Perspective taking (imagine-self), 7) Empathic distress, 8) Empathic concern.

More recently, Walther et al. [4] offered a three-part non-hierarchical model of empathy in engineering comprised of three interwoven dimensions. The *Skill* dimension is comprised of five "distinct, socio-cognitive processes that interact with each other to form the foundation for empathic communication, relationship-building, and communication" (p. 133), including perspective taking, affective sharing, self, and other awareness, emotion regulation, and mode switching. The *Orientation* dimension "captures a range of mental dispositions that influence how engineers and engineering students engage in practice situations" (p. 133) and includes dimensions of epistemological openness, micro to macro focus, reflective values awareness, and values pluralism. Lastly, the *Being* dimension "highlights the need to situate empathic skills, practice orientations, and their development within a contextualizing framework of broader values" (p. 134). The broader commitments Walther et al. [4] put forth include "service to society," "dignity and worth of all stakeholders," and "engineers as whole professionals."

Walther et al.'s [4] model aligns with Batson's [18] in representing empathy as a complex and multidimensional phenomenon. While Batson's [18] model presents different types of empathy, Walther et al.'s [4] model defined different facets of empathy which also may be important when we situate empathy in an engineering context (e.g., holistic service to society).

2) How has empathy been studied in engineering education?

The number of research studies on empathy in engineering education have grown rapidly over the past decade [20]. The primary domains of empathy research within engineering education include design, service-learning, communication, collaboration, and ethics [19]. These domains share a focus on interpersonal relationships and thus provide opportunities to develop empathy among engineering students.

For example, empathic design can help students understand users' needs and develop empathic and innovative tendencies [21]. Teaching empathic communication skills can help with conflict resolution, team-building, and effective listening [19]. Service learning pedagogies are another effective way to promote empathy [2], [22], [23] as well as civic learning [24]. Through service-learning, engineering students work on real-

world and contextualized projects oriented towards helping others, often community members.

3) How can we measure empathy?

Multidisciplinary empathy literature shows that empathy has been defined and measured in a variety of ways. Surveys and observations are two of the most common ways to measure empathy [25]. These measures tend to measure *empathic traits*, which represent the general likelihood that one uses empathy versus *empathy as a state* which draws attention to how individuals empathize in particular situations.

As Clark et al. [25] show, the Interpersonal Reactivity Index [26] is one of the most common instruments used to assess empathy in organizational contexts. Likewise, the IRI has also seen increased used in engineering education in recent years [23], [27], [28]. Davis [26] frames the IRI as a measure of individual *empathic tendencies* which aligns with the *trait* distinction offered by Clark et al. [25]. The IRI was designed to measure four empathic tendencies: 1) Perspective Taking, 2) Fantasy, 3) Empathic Concern, and 4) Personal Distress. In this study, we focus on Perspective Taking (PT) and Empathic Concern (EC). Davis [29] defined these two concepts as follows: "Perspective taking assesses spontaneous attempts to adopt the perspectives of other people and see things from their point of view… The empathic concern scale inquiries about respondents' feelings of warmth, compassion, and concern for others" (p. 2). We provide additional justification for using only these two constructs in the methods.

C. Connecting Civic-Mindedness and Empathy

Outside of engineering, multiple scholars have connected the phenomena of civic-mindedness and empathy. For example, Bringle et al. [30], one of the designers of the CMG Scale, studied the alignment between civic engagement, empathic sadness, and empathic anger. Herein, they suggested that empathic anger often focuses "on a longer-term perspective for correcting injustices for an individual or groups of individuals with a nonprejudicial attitude and openness to diverse others" (p. 11). This macro-focus of empathy aligns with ways of defining empathy in engineering [3], [4] which also supports a focus on the relationship between empathy and civics.

Palombaro et al. [31] found that civic-mindedness and empathy were related in the context of physical therapy students. Their findings indicated that following a service-learning experience, civic-mindedness increased while empathy remained constant. Based on their findings, they argued that civic-mindedness might have a "protective effect against empathy declines in health professions students" (p. 190).

While engineering education scholars have not explicitly connected empathy and civics, we see close connections between empathy and societal considerations [2]–[4]. As one example, the micro to macro *Orientation* offered by Walther et al. [4] suggests the importance of considering micro-level considerations in tandem with the macro as we implement empathic skills, such as perspective taking. Thus, defining macro-level (e.g., community, societal) needs requires engaging with local and individual stakeholder considerations. Likewise, civic-mindedness may require engineers to consider societal and community needs by extrapolating from individual and interpersonal considerations gleaned from local community members.

These sentiments align with Davis's [32] organizational model of empathy, wherein an individual's capacities and dispositions play an instrumental role in informing whether empathy manifests within specific encounters. In this study, we build directly on these findings to test the hypothesis that *civic-mindedness* might also serve as an antecedent to empathy.

III. Methods

A. Data Collection

1) Participant Overview

Data were collected in Fall 2019 from students enrolled in a first-year engineering course at a large, public university in the Midwest. We administered surveys with the Civic-Minded Graduate Scale and the Interpersonal Reactivity Index. We surveyed students twice with a pre-test at the start of the semester and a post-test at the end. Of the 576 students enrolled in the course, 368 students completed both the pre and post-surveys. In our sample, we excluded two outliers using the interquartile range method [33] for a sample size of 366; these responses were outliers on the outcome variables.

Table I reports the demographic information of our sample. The proportion of respondents by gender and race were representative of the undergraduate engineering student population at the institution.

TABLE I. Demographic Information of Survey Respondents (N=366)

Demographic Item	Number
Gender	
Man	270 (74%)
Woman	93 (25%)
Not Declared	3 (1%)
Race/Ethnicity	
American Indian or Alaska Native	0
Asian	96 (26%)
Black or African American	4 (1%)
Hispanic or Latino	13 (4%)
Native Hawaiian or Pacific Islander	0
White or Caucasian	221 (60%)
Other Race/Ethnicity	1 (0.5%)
Multi-Racial	22 (6%)
Not Declared	9 (2.5%)
Age (M, SD)	18.4, 0.62

B. Measures

1) Outcome Variable: Empathy

We operationalized empathy by using two of the four constructs from the Interpersonal Reactivity Index [26]. Though Davis [26] originally developed the Interpersonal Reactivity Index with four subscales, many studies exclude the Fantasy and Personal Distress subscales because they are generally not theoretically or empirically aligned with cognitive and affective empathy [34]–[36]. We followed this approach and only employed the Empathic Concern and Perspective Taking subscales. Empathic Concern contains seven items measuring one's feelings of concern towards others [26] and is commonly used to assess affective empathy [34], [36]. Perspective Taking contains seven items measuring one's willingness to see a situation from someone else's point of view [26] and is often linked with cognitive empathy [34], [36].

Students responded to items on a Likert Scale from 1 to 9 where 1 indicated strong disagreement and 9 indicated strong agreement. After reverse scoring some items, we averaged the items on each subscale to transform students' responses into a continuous composite score which was on the same 1 to 9 scale. Thus, a higher score suggests greater prevalence of the respective empathic tendency.

Using Confirmatory Factor Analytic procedures, Hess et al. [37] found that the removal of three items from the Empathic Concern subscale and one item from the Perspective Taking subscale led to more stable measurement models of these constructs. Thus, to determine whether to employ the original seven-item solutions or the reduced configurations, we performed these same procedures (like Hess et al. [37], we interpreted Satorra-Bentler modified outputs due to potential normality concerns). We found evidence that the reduced factor structures were acceptable for the Empathic Concern and Perspective Taking constructs for both pre and post-test responses, and thus we chose to use these reduced measurement models in this study. Notably, the complete seven-item measurement model for the *post* responses to Perspective Taking (with correlations between the error terms of PT_06 and PT_07) was slightly superior (χ^2 (13) = 16.85, p = .206, RMSEA = .027, TLI = .991) when compared to the six-item configuration (χ^2 (8) = 11.50, p = .175, RMSEA = .032, TLI = .990); however, the measurement model for seven-item configuration to the *pre* responses (with correlation between error terms for PT_02/PT_03 and PT_06/PT_07) was unacceptable (χ^2 (12) = 45.96, p < .01, RMSEA = .093, TLI = .904) whereas the six item configuration was acceptable (χ^2 (7) = 12.17, p = .095, RMSEA = .041, TLI = .983). (For a detailed discussion about the omitted items from each construct, please see Hess et al. [37].)

In our regression analyses, we generated two separate models with Empathic Concern and Perspective Taking subscales as separate outcome variables, both intended to measure empathy. We used students' scores from the post-test as the outcome variable. Moreover, post-hoc, we checked regression outputs with the reduced and seven-item model configurations, and we found the results were similar. Thus, the use of the reduced measurement models did not seem to significantly impact the regression results.

2) Predictor Variable: Civic-Mindedness

To measure our predictor variable(s), civic-mindedness, we surveyed students on the 30 items on the Civic-Minded Graduate Scale (Steinberg et al., 2011). Like the IRI, each item was scored on a Likert Scale from 1 to 9. We averaged all 30 items to transform each student's discrete Likert scores into a continuous composite score between 1 and 9. A score of 9 suggests a positive disposition towards civic-mindedness, whereas a score of 1 suggests a negative disposition towards civic-mindedness.

In additional to a unidimensional measure of civic-mindedness, we also scored student responses according to the five subscales of the Civic-Minded Graduate Scale. We averaged the items in each subscale to create a composite score for each of the five factors.

In this study, we operationalized civic-mindedness as both a unidimensional and factored construct. We constructed different models to compare the unidimensional and factored measures of civic-mindedness.

3) Control Variable: Baseline Empathy

We used the pre-test survey responses to establish a baseline for students' empathy scores. These baseline scores served as a control variable so we could understand how civic-mindedness predicted variations in empathy. In our models, we used students' pre-test empathy scores as a predictor in our model and their post-test empathy scores as the outcome variable. Our approach follows what Farmus et al. [38] calls a "regression-based model" and what Allison [39] calls a "regressor variable method". This method accounts for pre-test effects [38] and reduces the risk of a spurious correlation [39].

C. Data Analysis

In this study, we used multiple linear regression to predict variations in first year engineering students' empathic tendencies based on their civic-minded dispositions. We used RStudio version 1.4.1103 to conduct analyses.

We used Ordinary Least Squares Regression to generate our models. We report the estimated regression coefficients in each model and the standard error. We evaluated the estimated regression coefficients with hypothesis tests; the null hypothesis is that the regression coefficient b equals zero, whereas the alternative hypothesis is that b is significantly different from zero. To compare the models, we report the adjusted coefficient of determination (R^2), which represents the proportion of variance in the outcome variable explained by the predictor variables; the adjusted R^2 accounts for the number of parameters in the model.

IV. Results

A. Descriptive Statistics

Table II presents the mean, standard deviation, and internal consistency of the variables we use in our models. Outcome variables were the post-test scores of Empathic Concern and Perspective Taking, while the respective pre-test scores served as control variables. Our predictor variable was the post-test civic-mindedness score; we considered a unidimensional and a factored structure for measuring civic-mindedness. Thus, we compute distinct linear regression models based on these different structures.

TABLE II. DESCRIPTIVE STATISTICS OF VARIABLES (*N*=366)

Variable	Items in Subscale	Mean	SD	α
Empathy (post-score; outcome variable)	-	-	-	-
Empathic Concern	4	6.11	1.05	.79
Perspective Taking	6	6.20	0.95	.65
Empathy (pre-score; control variable)	-	-	-	-
Empathic Concern	4	6.37	1.21	.76
Perspective Taking	6	6.29	1.14	.78
Civic-Mindedness (unidimensional)	30	6.51	1.07	.95
Factor 1: Valuing Community Engagement	4	6.78	1.44	.90
Factor 2: Confidence in Influencing Social Issues	4	6.57	1.21	.74
Factor 3: Civic Knowledge and Skills	5	6.06	1.35	.84
Factor 4: Empathic Interpersonal Communication	4	7.40	1.12	.83
Factor 5: Civic Intentions and Obligations	4	6.05	1.60	.80

Note: Scores were measured on a Likert Scale of 1 (Strongly Disagree) to 9 (Strongly Agree). SD = standard deviation.

We checked the internal consistency of all variables using Cronbach's alpha. We do not present alpha scores as evidence of dimensionality of constructs, but rather as a type of evidence for internal consistency in our subscales [40]. Though Cronbach's alpha is higher for the unidimensional civic-mindedness compared to the five subscales, we do not assume civic-mindedness is a unidimensional construct; nonetheless, we compute both the unidimensional measure to recognize extant uses of the CMG Scale, as well as the five-factor model as prior work shows evidence of the structural validity of this model when used with engineering students [17].

We also checked the correlation between variables; the correlation matrix is shown in Table III. We discuss the results and impact of these correlations in subsequent sections about our regression models.

TABLE III. CORRELATION MATRIX OF VARIABLES (*N*=366)

	Empathy Variables				Civic-Mindedness Variables					
	EC post	EC pre	PT post	PT pre	CMG	Fac. 1	Fac. 2	Fac. 3	Fac. 4	Fac. 5
EC post	1	.72	.41	.60	.62	.57	.48	.36	.57	.42
EC pre	-	1	.48	.59	.45	.46	.36	.21	.46	.27
PT post	-	-	1	.55	.59	.51	.50	.38	.61	.35
PT pre	-	-	-	1	.41	.35	.31	.25	.44	.28
Fac. 1	-	-	-	-	-	1	.63	.54	.55	.54
Fac. 2	-	-	-	-	-	-	1	.53	.63	.52
Fac. 3	-	-	-	-	-	-	-	1	.46	.45
Fac. 4	-	-	-	-	-	-	-	-	1	.39

B. Regression Models

We generated eight multiple regression models to investigate the relationship between civic-mindedness and empathy. Four models considered Empathic Concern for the outcome variable while the other four used Perspective Taking as the outcome variable. Table IV summarizes the regression coefficients and associated standard errors for the predictor variables in each model. The following sections describe how we developed and tested each model.

1) Model 1

We first confirmed our hypothesis that empathy and civic-mindedness are linearly related to affirm that we could model their relationship through linear regression. Civic-mindedness was significantly correlated with both Empathic Concern (r = .618, p < .001) and Perspective Taking (r = .591, p < .001); these values also exhibited large effect sizes [41]. Fig. 1 and 2 show scatterplots of Empathic Concern and Perspective Taking scores, respectively, plotted with civic-mindedness scores to illustrate the linear relationship between the variables.

TABLE IV. REGRESSION MODELS PREDICTING EMPATHY WITH CIVIC-MINDEDNESS (*N*=366)

	Empathic Concern (EC)				Perspective Taking (PT)			
	Mod. 1	Mod. 2	Mod. 3	Mod. 4	Mod. 1	Mod. 2	Mod. 3	Mod. 4
Variable	***b (SE)***	***b (SE)***	***b (SE)***	***b (SE)***	***b (SE)***	***b (SE)***	***b (SE)***	***b (SE)***
CMG	.783 *** (.052)	.466 *** (.046)	-	-	.562 *** (.040)	.418 *** (.040)	-	-
Baseline	-	.545 *** (.035)	.523 *** (.037)	.519 *** (.037)	-	.322 *** (.036)	.278 *** (.036)	.277 *** (.036)
Factor 1	-	-	.120 *** (.044)	.137 *** (.040)	-		.109 ** (.037)	.139 *** (.031)
Factor 2	-	-	.021 (.054)	-	-		.074 (.047)	-
Factor 3	-	-	.036 (.0412)	-	-		.014 (.035)	-
Factor 4	-	-	.228 *** (.054)	.247 *** (.049)	-		.289 *** (.047)	.326 *** (.042)
Factor 5	-	-	.087* (.034)	.096 ** (.032)	-		.0002 (.036)	-
Constant	1.51 *** (.344)	.050 *** (.284)	-.153 (.314)	-.083 (.306)	2.68 (.265)	1.55 *** (.270)	1.10 *** (.280)	1.20 *** (.273)
Adjusted R^2	.380	.625	.623	.624	.350	.467	.50	.50

*Significant at p < .05, **Significant at p < .01, ***Significant at p < .001
Note: Regression coefficients (b) are unstandardized.

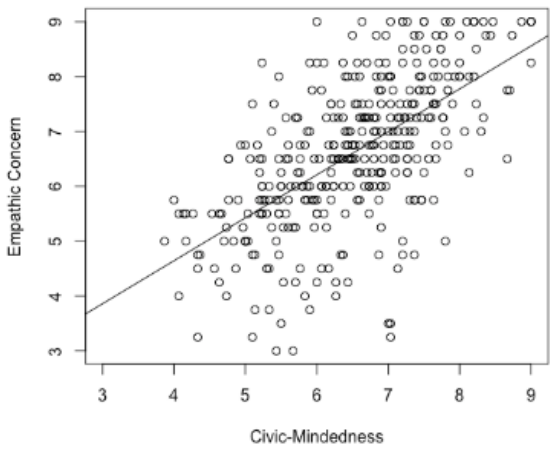

Fig. 1. Scatterplot of Empathic Concern and Civic-Mindedness scores for first-year engineering students

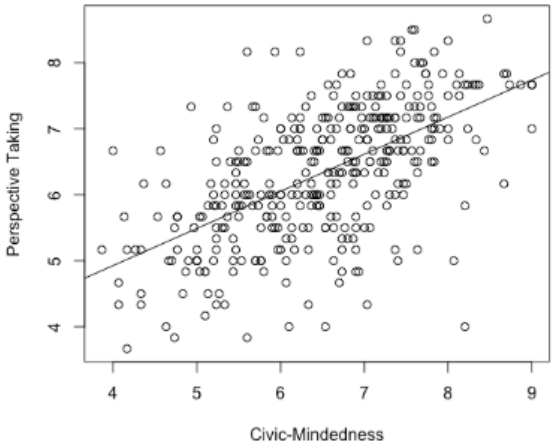

Fig. 2. Scatterplot of Perspective Taking and Civic-Mindedness scores for first-year engineering students

We used Ordinary Least Squares regression to model the linear relationship between the post-test empathy scores and the unidimensional civic-mindedness scores. Model 1 confirms our hypothesis that there is a significant linear relationship between civic-mindedness and Empathic Concern ($b = 0.783$, $p < .001$) as well as Perspective Taking ($b = 0.562$, $p < .001$) for the first-year engineering students in our sample.

2) Model 2

In Model 2, we added a control variable using students' pre-test or "baseline" empathy scores. Model 2 aims to explain variations in students' baseline empathy scores based on the unidimensional measure of civic-mindedness. In Model 2 with Empathic Concern as the outcome variable, civic-mindedness scores remained a significant predictor ($b = 0.466$, $p < .001$), though with a reduced regression coefficient compared to Model 1. The baseline scores were also significant ($b = 0.545$, $p < .001$). Civic-mindedness scores were also a significant predictor of Perspective Taking ($b = 0.418$, $p < .001$); the baseline scores were significant as well ($b = 0.322$, $p < .001$).

In the Empathic Concern models, adding this baseline measure of students' empathy scores in Model 2 explained 25% more of the variance than Model 1. For the Perspective Taking models, Model 2 with the baseline empathy scores explained 12% additional variance compared to Model 1.

3) Model 3

In Model 3, we deconstructed the civic-mindedness score into a five-factor structure. We treated each factor as a separate predictor variable in Model 3, rather than the unidimensional construct used in Model 2. In doing so, we could investigate the relative contribution of distinct facets of civic-mindedness to predicting students' empathy scores.

Since we introduced multiple predictor variables, we checked for multicollinearity in our data. While our predictor variables were moderately correlated, we found that the variance inflation factors were within acceptable limits to avoid the detriments of severe multicollinearity [15, p. 409].

We ran the model with all five civic-mindedness constructs as predictor variables and kept the baseline empathy scores as a control variable. For the Empathic Concern model, factoring civic-mindedness as separate predictor variables did not improve the fit of the model. For the Perspective Taking model, factoring civic-mindedness improved the model slightly by explaining 3% more variance.

In Model 3 for Empathic Concern, Factors 1, 4 and 5 were significant predictors in addition to the control variable, while Factors 2 and 3 did not add significant predictive value to the model. In Model 3 for Perspective Taking, only Factors 1 and 4 were significant predictors as well as the control variable. We further explored the significant predictors in Model 4.

4) Model 4

To generate Model 4, we used stepwise regression to refine Model 3 and determine which of the five civic-mindedness constructs were the most significant predictors of empathy. To model Empathic Concern, Factors 1, 4, and 5 remained significant factors in the model, while Factors 2 and 3 did not add significant predictive value to the model. We confirmed that Factors 2 and 5 could be dropped from the model with an ANOVA F-test ($F = 0.524$, $p = 0.593$). To model Perspective Taking, only Factors 1 and 4 remained significant factors in the model. We confirmed that Factors 2, 3, and 5 could be dropped from the model with an ANOVA F-test ($F = 1.09$, $p = 0.353$).

In Model 4, we simplified the model and reduced the number of predictor variables. For Empathic Concern, Model 4 explained the same amount of variance as Model 3 (62%) but with fewer predictor variables. For Perspective Taking, Model 4 explained 3% more variance as Model 3 with only two of the five factors.

In Model 4 for Empathic Concern, the three civic-mindedness constructs were significant predictors: Factor 1 – Valuing community engagement ($b = 0.137$, $p < .001$), Factor 4 – Empathic interpersonal communication ($b = 0.247$, $p < .001$), and Factor 5 – Civic intentions and obligations ($b = 0.0959$, $p < .01$). In addition, the baseline empathy scores remained significant ($b = 0.519$, $p < .001$).

In Model 4 for Perspective Taking, only two civic-mindedness constructs were retained and both were significant predictors: Factor 1 – Valuing community engagement ($b =$

0.139, $p < .001$) and Factor 4 – Empathic interpersonal communication ($b = 0.326$, $p < .001$). The baseline scores were significant as well ($b = 0.277$, $p < .001$).

C. Limitations

Empathy and civic-mindedness are multi-faceted, latent constructs that can be difficult to assess. We relied on two self-report measures: the first focused on two dimensions of empathy (empathic concern and perspective taking) and the second focused on select aspects of civic-mindedness. The interpretation of our results depends on the assumptions and validity of the instruments we chose.

1) Study sample

Our study sample was limited to first-year engineering students at a single institution; thus, we cannot generalize our results to the general population of engineering students. We also cannot infer how the relationship between empathy and civic-mindedness changes as students progress in their engineering programs.

2) Regression residuals

In our regression models, we observed that the residuals in all eight models had a mean of zero but were not normally distributed based on the results of Shapiro-Wilks tests. With our large sample size of 366, the non-normality of the residuals should not affect the estimated regression coefficients. The normality assumption of the residuals is most critical when predicting new observations and generating confidence intervals. The non-normality of the residuals may affect how precise the reported *p*-values are, though most regression coefficients in our models were significant at $p < .001$ [42], [43].

V. Discussion

In the results, we presented multiple linear regression models for predicting empathy from civic-mindedness among first-year engineering students at a single university in the midwestern United States. These models predicted Empathic Concern and Perspective Taking (as measured by the Interpersonal Reactivity Index [26]), which we consider related but different forms of empathy. In the discussion, we interpret our results to address our research questions and to theorize about the relationship between empathy and civic-mindedness.

A. Research Question 1: To what extent does civic-mindedness predict empathy in first-year engineering students?

We sought to address our first research question by generating two different measurement model configurations. First, we found significant linear correlations between a unidimensional measure of civic-mindedness and two measures of empathy: Empathic Concern and Perspective Taking. Second, we introduced one additional variable as a control: students' pre-test empathy scores. When we compared this second model with the first, we found that civic-mindedness explained an additional 22% of the variance in Empathic Concern and 24% of the variance in Perspective Taking beyond the variance that could be explained by using students' pre-test empathy scores.

These findings supported our hypothesis that civic-mindedness may serve as an antecedent to empathy, specifically the tendencies of Empathic Concern and Perspective Taking as measured by the IRI. This finding aligns with Davis' [32] organizational model of empathy, which proposes that numerous antecedents influence how empathy manifests within a given situation. Antecedents include one's dispositional tendencies to practice their capacity for empathy towards another [32].

Our findings support our hypothesis that civic-mindedness may act as one such disposition that can activate empathic tendencies, especially in social and community-oriented contexts. The feelings of obligation that lead one to serve their community can also inspire altruistic feelings and behaviors. This desire to help others has been shown to be associated with empathic concern and perspective taking [32]. Thus, one with civic-minded dispositions may be more inclined to empathize with others.

B. Research Question 2: What aspects of civic-mindedness are significant predictors of empathy in first-year engineering students?

To address Research Question 1, we used a unidimensional measure of Civic-Mindedness that consolidated 30 survey item responses into a single score. Research Question 2 sought to provide a more nuanced understanding of the relationship between civic-mindedness and empathy. Thus, to address this research question, we explored which specific aspects of civic-mindedness best predicted empathy by generating regression models using five factors of civic-mindedness as separate predictor variables.

We created two additional models to address this research question. Model 3 included all five factors, whereas Model 4 included only the factors that served as significant predictors of Empathic Concern and Perspective Taking. We found that the common significant predictors for Empathic Concern and Perspective Taking were Factor 1 (Valuing Community Engagement) and Factor 4 (Empathic Interpersonal Communication). We next unpack these findings, starting with Factor 4 as it was a stronger predictor.

1) Factor 4: Empathic Interpersonal Communication.

We expected Factor 4 to be a significant predictor for the empathy constructs because we theorized this factor was the most closely related to empathy. In our models, Factor 4 had the largest regression coefficient amongst the five civic-mindedness factors.

Factor 4 in the Civic-Minded Graduate Scale assesses students' self-reported interpersonal skills, including listening to other perspectives and responding to disagreement – one item even explicitly uses the term "empathy". The four Factor 4 items include:

- When members of my group disagree on how to solve a problem, I like to try to build consensus.
- I am able to respond to others with empathy, regardless of their backgrounds.
- I listen to others and understand their perspective on controversial issues.
- I am a good listener, even when people's opinions are different from mine.

These items in Factor 4 are especially distinct from other survey items because they do not explicitly include the term *community*. Though these items are not explicitly about community engagement, they represent skills that are important when working with community members [17].

For engineers, these interpersonal skills contribute to the success of community-oriented projects. Leydens and Lucena [2] argued that empathic listening skills are crucial for engineers as they engage in community development work. Through empathic listening, engineers can better understand the perspectives of people in the communities they work with and integrate the community's needs and concerns into their work. Empathic listening can help engineers empower community members with ownership over the project, which enhances the long-term success and sustainability of the project [2].

Even beyond community development projects, empathy is an important professional skill for engineers. For example, Walther et al. [4] argued that empathy is a professional skill that helps engineers navigate cross-cultural and global work environments. Separately, Hess et al. [44] found that many practicing engineers perceived empathy as "necessary skills if one is to thrive as an engineer," particularly in interpersonal activities such as "leading and managing others, working in teams, and communicating and listening" (p. 230).

Factor 4 of the Civic-Minded Graduate Scale connects civic-mindedness and empathy through a shared emphasis on the propensity or disposition to listen to and engage with perspectives that differ from one's own perspective.

2) Factor 1: Valuing Community Engagement.

Factor 1 was also a significant predictor of Empathic Concern and Perspective Taking. Factor 1 assesses students' feelings of obligation to serve their community and society. Factor 1 items include:

- I want to dedicate my career to improving society.
- I believe that I have a responsibility to use the knowledge that I have gained to serve others.
- I like to be involved in addressing community issues.
- I would say that the main purpose of work is to improve society through my career.

In contrast to the items in Factor 4, the items in Factor 1 explicitly use the terms *community* and *society* and do not mention empathy or related interpersonal skills. The significant linear relationship between Factor 1 and the empathy constructs in our models suggests that valuing community engagement can influence one's perspective taking and empathic concern tendencies. Thus, one who feels an innate desire to give back to or serve their community may also be more inclined to consider others' perspectives and become concerned with others' misfortunes.

We see this connection between service and empathy supported in Walther et al.'s [4] model of empathy, which conceptualizes empathy as a learnable skill, practice orientation, and professional way of being. In particular, the professional way of being dimension emphasizes the importance of tending to one's values. As they write, "Empathic skills and associated practice orientations cannot be developed by students or lived by engineers without the anchor of a contextualizing framework of broader value commitments" (p. 137). Thus, developing and practicing empathy requires a willingness to engage certain values – such as a commitment to "holistic service to society" – coupled with an openness to interrogate one's value commitments within the aims of the engineering profession. Though Walther et al. [4] did not explicitly label "holistic service to society" as civic-mindedness, this notion of service to society aligns well with our definition of a civic-minded engineer: one who acts upon their feelings of obligation to use their professional skills to improve the livelihoods of others.

Thus, Factor 1 of the Civic-Minded Graduate Scale relates civic-mindedness and empathy through their shared aims of understanding and realizing one's purpose in society.

VI. Conclusion

Empathy and civic-mindedness represent important skills and dispositions that enable engineers to effectively serve their communities and promote societal welfare. In this study, we explored the linear relationship between civic-mindedness and two empathy constructs (perspective taking and empathic concern) in first-year engineering students. We tested the hypothesis that civic-mindedness influences empathy and we developed different model configurations to understand the relationship between these dispositions. While we found an overall predictive relationship between civic-mindedness to empathy, the models that accounted for civic-mindedness factors revealed that Valuing Community Engagement and Empathic Interpersonal Communication were the primary predictors of Empathic Concern and Perspective Taking. This finding contributes to discourses about antecedents for empathy (e.g., Davis' model [32]) by suggesting that civic-mindedness is a value orientation that increases one's tendency to show empathy. These findings suggest that efforts to foster civic-mindedness in engineering students may also support the formation of their empathic tendencies. Though our models predicted empathy from civic-mindedness, we do not conjecture that their relationship is purely one-way. Empathy may also be an antecedent to develop civic-minded engineers, so it is important that we aim to develop both empathy and civic-mindedness in engineering students. A civic-minded and empathic engineer would be well-positioned to further engineering's aim of improving communities around the world.

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