

Educating Civic-Minded Engineers: A Qualitative Study of First-Year Engineering Students

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Abstract— This Work-in-Progress Research paper introduces a qualitative study about engineering students’ perceptions and experiences with civic engagement. This study extends the scholarship on civic engagement in higher education into a context that has received relatively little attention: the engineering profession. As professionals, engineers have a responsibility to serve public welfare and community interests. Engineers can contribute their skills to serve community needs and improve the livelihoods of community members. Postsecondary engineering education provides a valuable opportunity to help students develop an appreciation for the civic aspects of the profession. As a result, it is important to understand how engineering programs influence students’ civic-minded dispositions. Using a social cognitive approach, this study seeks to understand how civic mindedness manifests in engineering students’ pre-curricular, curricular, and co-curricular experiences and how these experiences shape their perceptions of civics within the engineering profession. This paper outlines the theoretical approach and research design of this study, including data collection methods and validity considerations. The paper concludes with a summary of future work.

Keywords—civic engagement, civic-mindedness, ethics

I. INTRODUCTION

Engineers serve at the forefront of technological advancements in society. As they define and develop technological solutions, engineers must uphold the safety and welfare of the public [1]. This commitment to the public is a hallmark of engineering, a defining characteristic shared with other professions. Service to the public good is what affords professions with the public’s trust and regard [2]. When professionals act against the interests of the public, perhaps in favor of the economic market or out of self-interest, the public may lose trust in the profession. To regain the public’s trust, professions need to avow and enact their commitment to serve public interests [3]. Recognizing the importance of fostering relations with the public, the National Academy of Engineering has sought to improve the public’s understanding of engineering [4] by bolstering the awareness of engineering social impacts.

Though language of public welfare may be embedded in the engineering profession, there is no singular “public interest” that engineers can serve. In reality, the “public” is a multifaceted conceptualization of the diverse, widespread clients and communities that engineers impact through their work [5]. One facet of the public that engineers serve is on the level of communities. Engineers’ commitment to serve their local (or global) communities can be framed in terms of their civic

obligations. Framing engineering in civic terms may not seem intuitive because the civic nature of engineering is not as clear as it is in other professions. For example, doctors and lawyers serve the healthcare and legal needs of members in their communities. In contrast, engineers serve a variety of clients and develop technologies that are not necessarily localized within a community. Nonetheless, engineers are often called upon to address community needs. To successfully do so, engineers must serve communities with respect and meaningfully involve community members in their work [6]. Engineers can harness their professional knowledge and skills to empower and improve the livelihoods of communities. Given the impact that engineers can have on communities, it is important to promote civic engagement in engineering. A natural place to strengthen the civic purpose of the engineering profession is undergraduate engineering programs.

A. Educating for Civic Engagement

Institutions of higher education are important arenas to instill future professionals with an appreciation for their civic responsibilities [2], [7]. Higher education provides a valuable opportunity to promote civic engagement because students learn the norms and values of the profession through their education [8]. Thus, Colby and Erlich [7] call upon institutions of higher education to prepare students for meaningful civic engagement. Broadly speaking, Colby and Erlich [7] define civic engagement as:

...working to make a difference in the civic life of our communities and developing the combination of knowledge, skills, values, and motivation to make that difference. It means promoting the quality of life in a community, through both political and nonpolitical processes.

For professionals (such as engineers) civic responsibilities also entail using one’s unique expertise to improve communities [2]. Thus, civic education aims to cultivate such civic responsibilities among future practitioners. Civic education is inherently normative because it embeds and transmits values of what it means to positively contribute to a community and be a good citizen; for example, civic education tends to emphasize democracy and justice [7], [9]. Similarly, engineering education also embeds values of what it means to be a good engineer.

B. Civics, Values, and Engineering Ethics

Values undergird and drive practice. In engineering education, the *values* that constitute what it means to be a good engineer and a good civic agent are often implicit. Weston [10]

defines values as “those things we care about, that matter to us; those goals and ideals we aspire to and measure ourselves or others or our society by” (p. 103). However, the values driving engineering practice need not be static. Instead, in the spirit of social justice, they should be openly debated, defended on moral grounds, and reaffirmed across the profession, educational institutions, individuals instructors, and the public [7], [9].

While civics is seldom an explicit lens or value brought to engineering, a commitment to the safety, health, and welfare of the public is often espoused [1]. Also, civic-related considerations often manifest in ethics frameworks, a much more common domain of inquiry of engineering (perhaps because it is a required component of engineering program accreditation). For example, Schmidt [11] advocates for a virtue ethics approach that foregrounds discussion of values. Here, whilst engineers make decisions that rely on their practical judgment and expertise, they recognize that underlying these decisions are moral virtues (and values) such as objectivity, care, and honesty. Harris [12] extends this virtue ethics approach and names values of a good engineer: technical excellence, technosocial sensitivity, respect for nature, and commitment to the public good. For these virtues to translate into the profession, they need to be properly integrated into engineering education.

Despite the potential for higher education to promote civic values, Colby and Sullivan [7] found that in many cases, higher education programs do not emphasize the moral standards and practices of the profession. In particular, they found that engineering programs placed the highest emphasis on developing students’ technical knowledge in math and engineering science. In many cases, instructors intentionally neglected ethical development [2]. In corroboration of this finding, Cech [13] found that engineering students’ appreciation for the engineering profession’s commitment to and concern for public welfare declined over the course of their undergraduate engineering education. Taken together, these findings suggest that engineering programs may not be cultivating a sense of civic purpose in their graduates. This gap warrants further exploration of the role of engineering education in promoting civic engagement for engineers.

C. Study Purpose

This study investigates first year engineering students’ perceptions of and experiences with civic engagement. We theorize that student dispositions towards civic engagement are formed during students’ experiences before college but are not static; rather, as Cech [13] found, these are further shaped (often negatively) by their curricular and co-curricular experiences in college. Moreover, we theorize that beyond college, these dispositions will influence how graduates engage in their communities and use their skills to serve others. We are specifically interested in students’ perceptions and experiences pertaining to civic-mindedness, which can be understood as the willingness to act upon feelings of obligation to serve a community [14]. Since we theorize that civic-mindedness is a desirable learning outcome for preparing a future workforce committed to making prosocial decisions in practice, it is important to understand how perceptions of civic engagement may change in college. Thus, we seek to understand how civic mindedness manifests in students’ pre-curricular, curricular, and

co-curricular experiences, and how these collective experiences impact students’ perceptions of the relationality between civic mindedness and the engineering profession.

We address the research question, “How do engineering students’ perceptions of civic mindedness change during their first year of college?” We focus on the first year of college because we are particularly interested in the transition from high school into college. This transition marks a shift in students’ community context, which new students will experience most saliently. Alongside their adjustment to college, students are also being socialized into the engineering profession. We are interested in understanding how student experiences within and early transitions to the college environment influences their civic engagement and civic attitudes, as well as their developing perceptions of the role of civics in engineering.

D. This Study in Context

Prior studies have explored the development of civic mindedness and civic learning outcomes among college students within an institutional context. This study extends prior work by studying civic mindedness within the context of a profession – engineering. While civic engagement has been studied in higher education, few studies have focused specifically on engineering students [15]. Morgan, Davis, and López [16] recently studied political engagement among engineering students. However, they conceptualized political engagement as related but distinct from civic engagement, with civic engagement focusing more on apolitical involvement. In the spirit of Colby and Ehrlich [7], this study considers civic engagement as encompassing both apolitical and political dimensions. The findings from this study will reveal engineering students’ perceptions of civic mindedness and experiences that may have shaped or shifted these perceptions. These findings can inform efforts to support the development of civic-minded engineers who are committed to serving their communities.

II. THEORETICAL FRAMEWORK: SOCIAL COGNITIVE THEORY

Because civic development occurs alongside other aspects of human development, theoretical approaches in developmental science are well suited to study changes in civic engagement. Developmental theories can be particularly valuable in understanding how attitudes, motivations, and behaviors towards civic engagement change over time, including during adolescence and the transition to adulthood [13]. In exploring civic development, we adopt a social cognitive approach.

Social cognitive theory emphasizes the social nature of learning; in other words, one’s environment, and agentic factors afforded by one’s environment, are integral to one’s learning and development. Bandura advanced this theory based on studies of observational learning, which showed that learners constructed knowledge by observing others’ behaviors. Thus, Bandura argued that knowledge construction does not necessitate physically or tangibly enacting a practice [18].

Bandura [19] theorized that self-efficacy “occupies a pivotal role in the causal structure of social cognitive theory.” Bandura [21] defined self-efficacy as a measure of one’s confidence in their ability to accomplish a goal. Self-efficacy is a major influence on learning and partially determines which activities people will dedicate themselves to. As Bandura writes:

It is partly on the basis of efficacy beliefs that people choose what challenges to undertake, how much effort to expend in the endeavor, how long to persevere in the face of obstacles and failures, and whether failures are motivating or demoralizing. (p. 10)

Thus, the decision to engage in a behavior is mediated by one’s belief that the behavior will result in a particular outcome and the degree of one’s competence to achieve that outcome [20]. Self-efficacy can play an important role in civic participation because one’s decision to engage in a civic activity, such as voting or volunteering, will be influenced by the extent to which one believes that activity will result in an desirable outcome [21].

In his social cognitive theory, Bandura [19] extended a tripartite conceptualization of agency (which plays a pivotal role in learning). These three parts include (1) perceived personal agency and its associated “cognitive, motivational, affective, and choice processes” (p. 13); (2) proxy agency, which emphasizes interpersonal dynamics and the role of others in helping one reach a desired outcome; and (3) collective agency, defined as “people’s shared belief in their collective power to produce desired results” (p. 14). The notion of collective agency is also prominent in civic participation, consistent with the role of community organizing in social change.

Social cognitive theory is particularly well suited to study civic development because it accounts for social influences on behavior as well as personal (i.e., cognitive and affective) factors. Because civic engagement is a social practice, this approach can help identify the underlying beliefs and motivations that encourage or discourage one from engaging in civic participation [21]. Social cognitive theory also accounts for the role of education and educational systems in shaping behavior. Bandura’s [18] perspectives on observational learning present education as a process of socialization. Students learn the norms and values of the engineering profession, whether implicit or explicit, based on the behaviors and attitudes they see modeled in their engineering programs. Thus, engineering programs play a pivotal role in encouraging (or discouraging) civic-mindedness and related dispositions.

III. RESEARCH DESIGN

To understand engineering students’ perceptions of and experiences with civic engagement, this study utilized a qualitative, interview-based research design. Interviews are well-suited to exploring perceptions because they tap into the emotional dimensions of participants’ motivations, beliefs, and behaviors [22]. In particular, Pugh [22] argues that from interviews, researchers can extract cultural meanings based on participants’ choice and use of language, their justifications or reasoning for their actions or attitudes, and emotional cues. These features of interviews convey information about how an individual relates to the cultural practices and norms of their social and communal context(s) [22]. In this study, the interview-based approach is useful for exploring how students construct and convey their relationships to civic participation and how these relationships evolve as a result of their experiences in college.

A. Data Collection

Interview participants include first year engineering students at a Midwestern public research university. Students were recruited from a large enrollment introductory course required for first-year engineering majors. Students were offered an incentive of a \$10 gift card to participate in an individual interview either in-person or online.

1) Participant Overview

Eleven students participated in interviews (see Table 1). Students were pseudonymized with names they chose or that we assigned when students opted not to choose a pseudonym. While the first eight interviews were conducted in-person, three subsequent interviews were conducted virtually through video conferencing due to the COVID-19 pandemic.

TABLE 1. OVERVIEW OF INTERVIEW PARTICIPANTS

Student	Gender	Interview Mode
Amelia	Female	In-person
Ethan	Male	In-person
Grace	Female	In-person
Isabella	Female	In-person
John	Male	In-person
Julia	Female	Virtual
Larry	Male	In-person
Leo	Male	In-person
Madison	Female	Virtual
Noah	Male	In-person
Sara	Female	Virtual

These eleven students came from varied backgrounds. Within this sample, most students were “out-of-state” (i.e., outside of the university’s state). In addition, one student shared a hometown with the university and another was an international student. Some students identified their hometowns as small towns, while others hail from larger metropolitan cities. These students also cover a range of civic experiences. Two students were actively involved in engineering-focused community service projects, while another student was in a community service fraternity. Many students were active in volunteering in high school, with some continuing to volunteer in college. A few students also engaged in local political activism.

2) Interview Protocol

The interview explored engineering students’ perceptions of civic engagement and the degree of their participation both during and before college, as well as future intentions. The interview followed a semi-structured format with prompts for follow-up questions when appropriate. After piloting the interview with a graduate student, the term “civic engagement” was replaced with “community involvement” as this was deemed potentially more familiar to students.

Interview Section 1. Community Involvement

As the term “civic” is not used explicitly in the protocol, we carefully worded questions to orient students towards the civic nature of community. For example, we chose to open the interview with the question: “What does it mean when someone is involved in their community?” Framing the early questions around community involvement directed student responses to a

focus on civics rather than other social communities, such as friend groups.

Interview Section 2. Civic Engagement

Beyond the opening questions about community involvement, the remainder of the protocol followed a structure adapted from the Civic-Minded Graduate interview protocol developed by Steinberg et al. [14]. Similar to their interview protocol, we focused on three forms of civic engagement: (1) volunteering and community service, (2) political involvement, and (3) advocating for social change. For each type of civic engagement, in alignment with social cognitive theory, we asked students questions about their experiences and motivations to participate.

Interview Section 3. Engineering and Civics

The third section focused on the intersection of engineering and civics. Here, we asked students to articulate the role and responsibilities of engineers in communities, their understanding of what engineers do, and what experiences shaped these perceptions.

3) Limitations of Interviews

As interviews were the primary data source for this study, it is important to recognize the limitations of interviews in addition to the advantages. The interviews represent accounts of behavior that may not accurately represent students' experiences or true motivations [23]. Specifically, because civic involvement is a socially desirable attribute, there is a risk of self-presentation bias in the data.

B. Validity Considerations

To strengthen the validity of our research design, we considered the quality framework for interpretive research proposed by Walther, Sochacka, and Kellam [24]. Walther et al. [23] created a process-oriented model to integrate validity considerations throughout all aspects of the research process, including the research design, theoretical framing, data collection, data analysis, and communication of results.

The first aspect of quality in this framework is **theoretical validity**, which aims for alignment between the research process (i.e., data collection, analysis, results, narration of results) and participants' lived experiences. If we look at the results alone, we might ask, "Do these data accurately reflect the participants' social realities?" One consideration of theoretical validation that we have and will continue to grapple with involves the framing of "community involvement" and its alignment with "civic mindedness." In addition, to strengthen theoretical validity, Walther et al. [23] recommend potential strategies, such as using purposive or theoretical sampling to select participants. Although we used convenience sampling and recruited from a single institution, we were able to form a sample with a wide range of civic-related experiences and background. As we develop our findings, we will also identify and explain contrasting cases within the themes we generate.

Second, Walther et al. [23] describe **procedural validity**, which focuses on the appropriateness of the research design. For this validation type, we might ask, "Did we take the

appropriate research steps to develop a holistic understanding of the phenomenon?" To seek procedural validity, we sought to verify participants' accounts of their beliefs and motivations towards civic engagement by asking them for specific examples to situate their claims within their own experience. By focusing on specific issues and experiences, we sought to reduce social desirability bias in participants' expressions and opinions. In the future, to reduce researcher bias, two independent coders will analyze the data.

Third, Walther et al. discuss **communicative validation**. This aspect considers various aspects of communication, both by the participants and the researcher. For example, we might consider the extent to which the data collection techniques allow participants to be forthcoming and to share their experiences fully. The data collection aspects vary between in-person and online, but we feel confident that both environments and the follow-up inquiries provided these conditions. In addition, this aspect might consider who the researchers ought to communicate the results to in order to ensure the language is appropriately interpreted when disseminated. We will seek to achieve this step through sharing results with others in our research community (i.e., through peer review).

Fourth, **pragmatic validation** seeks to ensure that the research process and the results reflect reality. This step might encourage researchers to consider whether the findings reflect their general observations and/or the realities of peripheral agents (i.e., course instructors).

Finally, **process reliability** seeks to minimize potential confounding effects or random influences. During data collection, we shifted from in-person to online interviews. As the pandemic is not an explicit aspect of interviews, it is not a necessary interview topic. Nonetheless, we will be attentive to any potential impacts of the COVID-19 crises in our analysis of interviews that occurred earlier and later in the semester.

IV. CONCLUSION AND NEXT STEPS

This work-in-progress paper presents the theoretical framework and research design for a study on first-year engineering students' civic-mindedness alongside validity considerations and techniques. Our immediate next step is data analysis. Using social cognitive theory as a guide, the authors will inductively develop a coding framework from the interview transcripts. The goal of the analysis is to generate themes related to the development of civic-mindedness during engineering students' first year of college. We are particularly interested in understanding changes in students' attitudes towards and participation in civic engagement during the transition from high school to college. We also seek to investigate how students relate civic mindedness to the engineering profession. The findings from this study will reveal engineering students' perceptions of civic mindedness and post-secondary experiences that may have shaped or shifted these perceptions. These findings can inform efforts to support the development of civic-minded engineers who will conscientiously serve their communities.

REFERENCES

- [1] "Code of Ethics for Engineers," National Society of Professional Engineers, 2007. [Online]. Available: <https://www.nspe.org/resources/ethics/code-ethics>.
- [2] A. Colby and W. M. Sullivan, "Formation of professionalism and purpose: perspectives from the preparation for the professions program," *University of St. Thomas Law Journal*, vol. 5, no. 2, p. 25, 2008.
- [3] W. Sullivan D. Jr., "Preparing professionals as moral agents." Carnegie Perspectives, 2004.
- [4] National Academy of Engineering, "Changing the conversation: Messages for improving public understanding of engineering," National Academies Press, Washington, DC, 2008.
- [5] Y. Lambrinidou and N. Canney, "Engineers' imaginaries of 'the public': Content analysis of foundational professional documents," in *2017 ASEE Annual Conference & Exposition Proceedings*, Columbus, Ohio, Jun. 2017, p. 28267, doi: 10.18260/1-2--28267.
- [6] J. Schneider, J. A. Leydens, and J. Lucena, "Where is 'Community'? : Engineering education and sustainable community development," *European Journal of Engineering Education*, vol. 33, no. 3, pp. 307–319, Jun. 2008, doi: 10.1080/03043790802088640.
- [7] A. Colby and T. Ehrlich, "Preface," in *Civic responsibility and higher education*, T. Ehrlich, Ed. Westport, CT: The American Council on Education and The Oryx Press, 2000, pp. v–x.
- [8] G. Dall'Alba, "Learning professional ways of being: ambiguities of becoming," *Educational Philosophy and Theory*, vol. 41, no. 1, pp. 34–45, Jan. 2009, doi: 10.1111/j.1469-5812.2008.00475.x.
- [9] P. Levine and A. Higgins-D'alessandro, "Youth civic engagement: normative issues," in *Handbook of Research on Civic Engagement in Youth*, L. R. Sherrod, J. Torney-Purta, and C. A. Flanagan, Eds. Hoboken, NJ, USA: John Wiley & Sons, Inc., 2010, pp. 115–137.
- [10] A. Weston, *A 21st century ethical toolbox*, 2nd ed. New York, NY: Oxford University Press.
- [11] J. A. Schmidt, "Changing the paradigm for engineering ethics," *Sci Eng Ethics*, vol. 20, no. 4, pp. 985–1010, Dec. 2014, doi: 10.1007/s11948-013-9491-y.
- [12] C. E. Harris, "The good engineer: Giving virtue its due in engineering ethics," *Sci Eng Ethics*, vol. 14, no. 2, p. 153, Jun. 2008, doi: 10.1007/s11948-008-9068-3.
- [13] E. A. Cech, "Culture of disengagement in engineering education?," *Science, Technology, & Human Values*, vol. 39, no. 1, pp. 42–72, Jan. 2014, doi: 10.1177/0162243913504305.
- [14] K. S. Steinberg, J. A. Hatcher, and R. G. Bringle, "Civic-minded graduate: a north star," *Michigan Journal of Community Service Learning*, vol. 18, no. 1, pp. 19–33, 2011.
- [15] R. J. Reddick, L. E. Struve, J. R. Mayo, R. A. Miller, and J. L. Wang, "'We don't leave engineering on the page': Civic engagement experiences of engineering graduate students," *Journal of Higher Education Outreach and Engagement*, vol. 22, no. 2, pp. 127–155, 2018.
- [16] D. L. Morgan, K. B. Davis, and N. López, "Engineering political fluency: Identifying tensions in the political identity development of engineering majors," *J. Eng. Educ.*, vol. 109, no. 1, pp. 107–124, Jan. 2020, doi: 10.1002/jee.20300.
- [17] B. Wilkenfeld, J. Lauckhardt, and J. Torney-Purta, "The relation between developmental theory and measures of civic engagement in research on adolescents," in *Handbook of Research on Civic Engagement in Youth*, L. R. Sherrod, J. Torney-Purta, and C. A. Flanagan, Eds. Hoboken, NJ, USA: John Wiley & Sons, Inc., 2010, pp. 193–219.
- [18] A. Bandura, *Social learning theory*. New York, NY: General Learning Press, 1971.
- [19] A. Bandura, "Social cognitive theory: An agentic perspective," p. 28, 2000.
- [20] A. Bandura, "Self-efficacy: Toward a unifying theory of behavioral change," *Psychological Review*, vol. 84, no. 2, pp. 191–215, 1977.
- [21] A. Metzger and J. G. Smetana, "Social cognitive development and adolescent civic engagement," in *Handbook of Research on Civic Engagement in Youth*, L. R. Sherrod, J. Torney-Purta, and C. A. Flanagan, Eds. Hoboken, NJ, USA: John Wiley & Sons, Inc., 2010, pp. 221–248.
- [22] A. J. Pugh, "What good are interviews for thinking about culture? Demystifying interpretive analysis," *Am J Cult Sociol*, vol. 1, no. 1, pp. 42–68, Feb. 2013, doi: 10.1057/ajcs.2012.4.
- [23] C. Jerolmack and S. Khan, "Talk is cheap: Ethnography and the attitudinal fallacy," *Sociological Methods & Research*, vol. 43, no. 2, pp. 178–209, May 2014, doi: 10.1177/0049124114523396.
- [24] J. Walther, N. W. Sochacka, and N. N. Kellam, "Quality in interpretive engineering education research: Reflections on an example study: quality in interpretive engineering education research," *J. Eng. Educ.*, vol. 102, no. 4, pp. 626–659, Oct. 2013, doi: 10.1002/jee.20029.