Educators' Perceptions of the Influence of Academic Environment on Ethics Education: A Comparative Case Study of Two Engineering Departments

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***Abstract*—This full research paper explored the relationship between academic environment and faculty members' perspectives on ethics instruction. Ethical responsibility and awareness of the societal impacts of technology are crucial learning outcomes for future engineers. The study and practice of ethics are convergent since the subject draws on engineering and the humanities with the aim of positioning students to responsibly address the most pressing societal challenges. In the curriculum, faculty members' decisions regarding course content, including those related to ethics and societal impacts (ESI), result from a host of factors including influences at the department, college, and institutional levels. This exploratory study examined engineering faculty members' perception of their academic environment in relation to ESI education via a comparative case study of two engineering departments. The mixed-methods design included faculty interviews and surveys to understand participants' perceptions of culture, leadership, and curricular importance related to ESI. The study also employed document analysis to contextualize the formal inclusion of ESI and to triangulate the findings. The data suggested the influence that culture and leadership, especially at the department level, exert on perceptions of support for ESI instruction. Across both departments, the data indicated the high value that faculty place on ESI in engineering education. The findings suggest the importance of establishing both bottom-up and top-down support for ESI education and creating a culture in which espoused values align with formal structures and policies. With increasing attention paid to the inclusion of ESI and growing responsibility on engineering faculty, it is important to acknowledge the environment in which educators develop their instructional practices and perspectives.**

Keywords*—*Mixed methods research, Case study, Ethics, Faculty, Institutional Culture

I. Introduction

Ethics and societal impacts (ESI) education in engineering has gained momentum over the past couple of decades [1]. ESI encompasses microethics, the duties and decisions of individual engineers, and macroethics, the responsibilities of the engineering profession to society [2]. Both domains have been integrated into student outcomes for engineering programs accredited by ABET [3]. However, institutions, programs, and educators have considerable autonomy in how they meet accreditation requirements. The perceptions of engineering educators regarding the importance of ESI are the confluence of a range of interrelated influences. This research was designed to understand how influences at the department, college of engineering, and institutional levels affect engineering faculty's perspectives on culture and leadership related to ESI education. This research conceptualizes culture as "the shared values, assumptions, beliefs, and ideologies that members have about their organization or its work" (p. 6), which provides a definition of academic culture that stems from studies in organizational behavior and theory [4].

II. Background

The nature of engineering and the socio-technical context in which it is embedded necessitate ethical responsibility in the profession. In engineering, like other professions such as health, law, and business, the importance of ethics in practice warrants its inclusion in education [5]. Practicing engineers have reported encountering ethical issues in their work; feeling unprepared to address such challenges; and feeling that engineering students should be exposed to ethics in their academic training [6]. Since professional ethics include issues unique to their vocation, different curricular strategies and pedagogies are employed [5]. Within engineering, ABET mandates that accredited programs demonstrate their students' "ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economics, environmental, and societal contexts" (criterion 3, outcome 4; [3]). Although external forces such as the National Academy of Engineering, industry, and ABET recognize the importance of ESI, there often appears to be a misalignment between the expectations of the profession and realities of the curriculum [6], [7].

Engineering programs have considerable autonomy over decisions regarding where and how ESI are integrated into the curriculum. Despite the "tremendous variation in the kind, amount, and intentionality of coverage of ethical issues" [8] (p. 332), many programs build from a similar foundation. Common curricular integration strategies include a module in engineering science or design courses, a required course in ethics, and ethics integrated across-the-curriculum [8], [9], [10]. Dominant pedagogical trends include ethical frameworks, such as codes of ethics and moral theories, and case studies [8], [9], [10], [11]. Most of the content focuses on individual responsibilities and decisions, as opposed to the broader, macroethical responsibilities of the profession to society and the socio-environmental impacts of technology [9].

In their multi-case study exploration of ethics in engineering programs at seven US institutions, [8] concluded,

> few of the departments we visited seemed to establish explicit goals in this area [engineering ethics] or monitor and coordinate coverage. It was commonplace in our site visits for faculty, even department chairs, to be unaware of whether or how their program supports its students' development of professional responsibility or ethics (p. 332).

To improve instructional efficacy and students' professional preparation, it is important to broaden the definition of ethics [12]; include ESI with other learning goals [13]; and increase the intentional integration of ESI in engineering [14]. To achieve these aims, faculty engagement is essential [8]. The literature thus suggests the need to further explore the role of engineering faculty and their environment in ESI education.

This research addressed the following research questions:

(1) What are the institution, college, and department cultures experienced by engineering faculty related to ESI education?

(2) What are engineering faculty members' perceptions of the importance of teaching ESI?

III. Methods

A. Study Overview

This exploratory study was situated in a broader project on ESI education that included an online survey of faculty and staff that collected 1448 responses from over 418 institutions in Spring 2016 (for additional information see [15], [16]). On the survey, 230 respondents expressed willingness to participate in a follow-up interview. From this group, 37 educators across 35 institutions were interviewed (additional information provided in [17]). Near the end of the interview, participants were asked to describe the culture at their institution related to the ESI education of engineering students. Responses to this question served as the foundation for case selection. This research employed a case study methodology through the in-depth exploration of two distinct contexts. This study uses a multi-case approach [18] with two departments selected as cases to represent variation in the ESI culture.

B. Case Selection

Two departments were chosen for this case study research because they appeared to represent divergent cultures despite having similar institutional characteristics: both embedded in public, research-intensive universities. The chemical and biological engineering department serving as Case A was described as supportive and the electrical and computer engineering department serving as Case B was described as resistant to ESI education. During a site visit to Case A, interviews were conducted with two additional faculty members in the department. These interviews corroborated the initial description of a culture that encouraged and supported ESI instruction. A second interviewee from Institution B, but in a different department, perceived the culture in the college of engineering and institution as encouraging ESI education but similarly found that faculty in individual engineering departments perceived ESI as outside the realm of technical engineering that should be taught. The case selection was thus guided by theoretical replication: contrasting results (different perceptions regarding support for ESI) for predictable reasons (variations in culture) [19].

C. Data Collection

The methods were included in a protocol approved by the Institutional Review Board for Human Subjects Research. The case study methodology involved a mixed-methods design [19].

The first phase was qualitative with data derived from faculty interviews. After the initial 37 interviews and selection of the two cases, a snowball sampling strategy [20] was used to expand the number of interviews at both cases. The initial faculty participants from each department were emailed and asked for names and emails of colleagues in their department who are not actively involved in ESI education. The faculty member at Case A sent three recommendations and the faculty member at Case B recommended seven colleagues (including one self-described "ally" in ESI instruction in the department). All of the suggested colleagues were emailed and invited to participate in an interview on ESI education in engineering, whether or not they personally engage in it. The participants were offered a $50 Amazon gift certificate for participating. Two of the three educators at Case A responded and completed an interview. The seven educators at Case B were sent an initial and follow-up invitation but only one (the "ally") responded and completed an interview. The in-depth and semi-structured interviews [21] were conducted by the first author in November and December 2018. In all, five interviews were conducted for Case A; the initial participant, two faculty members interviewed during the site visit, and two faculty members recruited from the snowball sampling. These interviewees included one professor, two associate professors, and two assistant professors. At Case B only two interviews were conducted (the initial participant and the colleague recruited from the snowball sampling), and both were emeritus professors.

Due to the low representation of faculty interviewed for Case B, a quantitative method was employed as the next phase. The name, rank, gender, email address, and year and country of Bachelor's degree for each faculty member were compiled by the first author from the respective department websites. An online survey invitation was emailed to all faculty within the two departments (tenured and tenure track [T/TT], instructors, research faulty, and emeritus). The respondents were invited to take the survey on February 6, 2019 (wave 1) with reminders sent to unfinished respondents on February 14 (wave 2) and February 25 (wave 3). The survey closed on March 2, 2019. The survey questions were primarily Likert-type and related to perceptions of the importance of teaching ethics and societal impacts in engineering and the culture experienced by faculty teaching ESI using items adapted from [22], [23], [24], and [25]. Participants could elect to provide their email address if they wanted to be entered into a lottery for a $100 Amazon gift certificate; one certificate was available for each department.

At both institutions, responses were received from professors, assistant professors, and teaching faculty. From Case A, all received their Bachelor's degrees from US institutions and 40% of the respondents were female. Of the Case B respondents, 33% received their Bachelor's degrees outside of the US and 21% were female. The response rate from Case A (68%) was much higher than Case B (15%) (Fisher's exact test, two-tailed $p < 0.0001$). Low response rates raise concerns regarding nonresponse bias [26], which can lead to altered inferences about the relationships between variables [27]. The framework developed by [27] was implemented to examine the potential for nonresponse bias. One technique is to compare the characteristics of the sample to the population, which is the most common approach for assessing nonresponse bias. We compared the rank, gender, decade in which Bachelor's degree was awarded, and country in which Bachelor's degree was awarded (inside or outside the US) for those who were invited (population) and responded (sample). There were no statistically significant differences, suggesting no evidence of nonresponse bias. A second technique recommended by [27] is wave analysis to compare respondents from each wave of survey reminders. We used the initial invitation and two reminders and compared survey responses from individuals in the three waves for each department. There were statistically significant differences for 6 of the 27 survey items for Case A and no statistically significant differences for Case B.

Low interest in a survey topic has been associated with low response rates [28]. This relationship can be explained by the leverage-salience theory, where the survey "topic is particularly likely to lead to 'nonignorable' nonresponse, that which produces nonresponse error" [26] (p. 3). The difference between the response rates suggests lower interest in the survey topic within the department faculty at Case B. There are not expected to be differences in salience based on sender (the second author emailed out the survey invitation and is not from the institution nor discipline of either case) or incentive.

The third method embedded in the case study methodology was document analysis to "provide data on the context within which research participants operate" and aid convergence [29] (p. 30). Documents included mission and vision statements, educational objectives, general education requirements, program outcomes, course descriptions, and faculty directories.

In summary, the overall research approach was:

National survey (n=1448) → National interviews (n=37) → Case study selection based on theoretical replication (n=2) → Additional faculty interviews (n= 4 for Case A, n=1 for Case 2) → Department survey → Document analysis

D. Data Analysis

The faculty interviews were audio recorded and transcribed. The transcripts were imported into Dedoose for qualitative analysis by the first author using the constant comparative method [30]. The seven transcripts were broken into smaller units of analysis (segments) and labeled with a thematic code. Some codes were developed *a priori* based on the research questions while others emerged in the data, reflecting deductive and inductive coding, respectively. Throughout the analysis, comparisons were made between and within the transcripts. A preliminary codebook was created after the first iteration, which was used to revisit all the transcripts to develop a final codebook. Multiple coding [31] was used for reliability whereby the codes and a sub-set of segments (25 of 150) were shared with the second and third authors. The three authors met in-person to read each segment and discuss its thematic codes until convergence was reached.

For analysis of the survey data, nonparametric statistics (median and mean rank) were used since the data did not meet the assumptions of a normal distribution [32]. The Mann-Whitney U Test was used to compare the two independent samples (respondents from each department). Mann-Whitney is appropriate when the sample is small and not normally distributed [33]. As a nonparametric test, the Mann-Whitney compares the mean rank by ranking all values in the independent samples from low to high. Responses to the open-ended question at the end of the survey were analyzed using emergent, thematic coding [21].

The documents were analyzed using a combination of content and thematic analysis [29]. The content analysis involved a first-pass review, which identified relevant portions of the documents and categories related to the research questions. Thematic analysis was conducted to recognize patterns in the data and emergent themes. The purpose and audience of the documents were also noted.

E. Limitations

One important caveat in this analysis is the influence of discipline. Disparate cultures have been acknowledged among engineering disciplines [34] and may influence ESI education. Previous research identified differences in the extent that the ESI-related topics of safety, environmental protection issues, decisions under uncertainty, and sustainability were taught by engineering faculty in 13 disciplines, controlling for individual and institutional confounding variables [16]. For example, 60% of chemical engineering respondents taught environmental protection compared to 17% in electrical engineering. Katz and Knight [24] found that electrical engineering faculty emphasized the importance of ethical issues in their courses less than faculty in other disciplines but beliefs that ethical issues should be included in multiple courses were not statistically different between electrical and chemical engineering faculty. Despite these disciplinary differences, the code of ethics for chemical engineering [35] and electrical engineering [36] both include that members must "hold paramount the safety, health, and welfare of the public", protect the environment, treat all people fairly, and not engage in discrimination or harassment. Considering this rival explanation, in which discipline rather than department environment contributes to differences in ESI education, is part of establishing internal validity [19] but broadly comparing the practices and perspectives across disciplines is beyond the scope of this paper.

IV. Results and discussion

The quantitative results and qualitative findings are integrated to address the two research questions in the following sections.

A. *RQ1: What are the institution, college, and department cultures experienced by engineering faculty related to ESI education?*

The research explored the culture at the institutional, college, and departmental levels to understand if these environmental factors were influential in faculty's perspectives related to ESI. The respondents were asked "Describe the culture experienced by faculty teaching ethics and societal impacts to engineering and computing students: (1) At your institution, (2) at your college, and (3) in your department." The survey did not define culture, so the responses were based on the participants' interpretation of culture at these three levels. The scale for these items was anchored at 1 (very unsupportive), 3 (neutral), and 5 (very supportive). Regarding leadership, the respondents were asked to rate their agreement that (1) The college dean is supportive of teaching ethics and societal impact topics, (2) The department head/chair is supportive of teaching ethics and societal impact topics, and (3) Other faculty in the department/program are supportive of teaching ethics and societal impact topics. The scale for these questions was anchored at 1 (strongly disagree), 3 (neutral), and 5 (strongly agree). The ratings from the faculty survey responses are shown in Table 1.

TABLE 1: Ratings of culture

Survey Item	Case A		Case B		Mann Whitney p
	Median	Mean Rank	Median	Mean Rank	
Culture					
Inst.	4	19.5	4	18.6	0.819
College	4	21.7	4	18.1	0.344
Dept	5	23.7	4	16.7	0.059*
Leadership					
Dean supportive	5	21.3	4	17.4	0.290
Dept head supportive	5	23.8	4	16.9	0.078*
Dept faculty supportive	4	22.6	4	17.5	0.172
					*p<0.1

For Case A, perceptions of support increased from institution to college to department. The opposite trend is apparent for Case B with the highest mean rank for institution and lowest for department. The faculty perception of departmental culture related to ESI teaching was different between the two cases, with a 90% confidence level ($p<0.1$). This significance level to infer difference is not atypical for analysis of small datasets [37]. College and institutional support for ESI teaching are not perceived to be different between the two cases.

One manifestation of culture in higher education is faculty evaluations and promotion and tenure reviews. These policies inform the key relationship between what those in leadership positions "say is of value and what they actually reinforce… the processes… that most effectively establish organizational culture" [38] (p. 272). Survey respondents were asked to rate their agreement that "ethics and societal impacts teaching are valued during annual evaluation reviews" and "…during promotion and tenure reviews." For these two questions, there was a median of 3 (moderate agreement) across both cases. This result suggests the perception that ESI instruction is not highly weighted in these processes, which can serve as a motivational barrier for faculty, especially those who are pre-tenure.

<u>Institution:</u> At the institutional level, document analysis supported the similarity in culture reflected in the survey responses. Both have land grant missions that espouse commitment to engagement, learning, serving their community, and enhancing the lives of others. This result is unsurprising as there is little diversity in mission and vision statements generally and most institutions follow a certain typology with similar values [39].

Interviews with respondents in both cases suggested a strongly supportive institution-level culture related to ESI education. Two interviewees at Case A described university leaders as helping create institutional support for ESI education. One interviewee explained, "I do believe our values trickle down from the top" and cited university policies on academic misconduct and practices related to local sourcing and ethical farming for food on campus as examples. Another interviewee from Case A noted the support of university administration and its positive effect on his teaching,

> the messaging that they're getting across is that this is very important and they're very encouraging of faculty like myself. So there's a, I think, administratively or top down push to try to do more of it.

An educator at Case B described how the campus-wide emphasis on professional responsibility supported ESI education and facilitated collaboration across departments.

> So, ethics education at [Institution B] is actually, it's pretty positive… It's actually been nice that I've been able to talk to people in many departments… the idea is of professional ethics is absolutely ingrained across the campus. [Case B]

College: Both cases had a median rating of 4 for support through the college culture and the mean ranks were statistically similar. All five interviewees from Case A mentioned the dean when asked "How would you describe the culture at your institution in regards to the education of engineering students on ethics and societal impacts?" Culture was not defined by the interviewer in order to elicit participants' own understanding of the term. One interviewee, the department head of Case A, noted that the department was motivated to include ESI beyond minimal compliance required for ABET and noted, "the push that I feel to make sure that we teach ethics robustly… come from the College of Engineering Dean." Another interviewee who teaches ESI in the context of sustainability, noted,

> I feel a large amount of encouragement from certainly the department head and dean in integrating ethics issues into engineering coursework. Based on getting feedback that I receive both formally and informally, they're very receptive of this, appreciative in fact. [Case A]

Two of the Case A interviewees cited the dean's support for women and creation of a culture that fosters diversity and inclusion, which is a tenet in the chemical engineering code of ethics [35]. Inclusiveness is included as one of the college of engineering's core values. A male interviewee noted that the dean "really openly pushes women's involvement in engineering" and a female interviewee explained that the tone set by the dean created a "college culture [which] is fabulous in terms of supporting women and helping… males realize the value of diverse groups of people." One interviewee noted that the creation of this culture was facilitated by a personal change for the dean,

> He said basically that he always thought there was someone else's job to handle ethics and broader societal impacts. But now he's starting to see it as an obligation that we have as engineers and I thought that was really a cool thing to hear.

These quotes indicate the participants associated the actions and values of the dean with a supportive culture that they then linked to the education of engineering students regarding ESI. With a leadership role and ability to set the tone for the college, the dean was instrumental in creating a culture that supported ESI instruction.

When the interviewees at Case B were asked about environmental culture, they focused on departmental and institutional level and with only two interviews, no conclusions could be drawn about the college level.

Department: Two questions on the survey revealed a stronger perception of department level support for ESI at Case A versus Case B (Table 1). This finding is corroborated by the results from the survey question that asked the percentage of faculty in the department who teach ESI. At Case A, the median response was that over half of the faculty teach ESI, compared to a median of 10-25% at Case B.

The interviews shed light on the divergent perceptions of department culture for the two cases. All five of the interviewees from Case A expressed that the positive department culture related to ESI education stemmed from the nature of the faculty within it. The faculty value ESI instruction and share a commitment to it in their courses. One interviewee expressed, "I do feel like we've established a faculty that all individually perceive it as our obligation to integrate ethics into our courses to the extent that we can." Another interviewee echoed, "I think every faculty tries to incorporate it somewhat into their class." As a result, the integration of ESI into the engineering curriculum had emerged bottom-up. A third interviewee explained the development of this culture, "It's not necessarily top down, it's more like as a faculty we've had a discussion and people kind of agree that it's important." The department head explained this ethics across the curriculum approach:

> We've found that the best, most effective way for us to do ethics is not a single class or a single part of a single class but multiple, multiple times… It's my job and it's our job as a faculty to make sure that ethics is comprehensively covered and the way that we achieve that is … content in multiple classes. [Case A]

The department at Case B was described as not supportive in the initial interview that was used to select the case for further exploration. When asked about challenges in developing and teaching courses related to ESI, the interviewee shared obstacles in the department.

> There's fierce resistance from the rest of the Department of Electrical and Computer Engineering… The faculty generally believe that engineering knowledge, all engineer knowledge, is technical. They seem not to understand that engineering ethics is part of the non-technical knowledge that engineers need to have… [Case B]

The other interviewee, who served on the curriculum committee when ABET EC2000 was introduced, described similar resistance from colleagues. The interviewee explained that the inclusion of ethical responsibility in program criteria generated extensive discussion and revealed the department's lack of value on this outcome.

> …the typical kind of statement is, 'I show ethics by my wonderful teaching example' and 'oh of course I bring it in, I do this or that,' All of which was pretty meager, grasping at straws really without putting any ethics in there…But there really was a very strong sense that trying to teach ethics was not worthwhile because it's not technical… There was definitely a feeling there's not room in our program for it. So basically how can we get past … this ABET requirement and not do anything. [Case B]

The department decided that the accreditation criterion would be fulfilled with one week of ethics instruction in a sophomore-level course that the interviewee taught. Confronted with the accreditation requirements, "the directive from the department was basically none. It was save our department 'til we get ABET accredited." The department had a culture of minimal compliance that did not support the sole educator who was tasked with teaching ethics. In response to the open-ended prompt on the survey, one educator at Case B noted "only [a] fraction of students takes a course with substantial content on engineering ethics and mainly if the course satisfies a requirement, e.g., for general education or honors program."

It is important to note the temporal limitations of the interview perspectives. Since the only two educators at Case B who participated in the interviews are faculty emeritus, the findings may not reflect the current state of the department culture. One interviewee alluded to this change saying, "I think the department is becoming stronger." The interviewee went on to explain if the ABET accreditation criteria change had been introduced under the recent department head's leadership, "he would have done a much better job of talking to the faculty and supporting and saying, explaining, why this is a good idea." For example, review of current documents showed the outcomes were expanded beyond ABET A-K to include ethics and sustainability as design constraints and the educational objectives include high ethical standards whereas the archived catalog from Case B in 2003 listed the program outcomes as the same as ABET EC2000 and shows one of the educational objectives included ethics.

B. RQ2: What are engineering faculty members' perceptions of the importance of teaching ESI?

The second research question sought to understand how the environmental factors around culture may have translated to the outcome of value placed on ESI education. The respondents were asked "Rate the importance of teaching ethics in engineering education" and "Rate the importance of teaching the societal impacts of engineering and technology in engineering education" on a scale from 1 (very unimportant) to 9 (very important). The survey results are summarized in Table 2, with the mean rank within the pooled 39 responses.

TABLE 2. Ratings of importance

	Case A		Case B		Mann Whitney p
Importance of teaching:	Median	Mean Rank	Median	Mean Rank	
Ethics in eng ed	8	18.9	9	20.7	0.638
Societal impacts in eng ed	8	18.5	9	20.1	0.687

The data indicated respondents from both cases rated ethics and societal impacts as highly important, and there was no significant difference between the two cases. Respondents were also asked to "Rate the importance of ethics in engineering education relative to math, science, and engineering science content" and the same for the societal impacts of technology. For the two cases, faculty rated both ethics and societal impacts of technology as equally important relative to math, science, and engineering science content in engineering education. For these questions, both cases had a median of 5 (equally important) on the scale from 1 (significantly less important) to 9 (significantly more important).

The results are encouraging in terms of the value that engineering faculty place on ESI in engineering education. There were eight total responses to the open-ended prompt, "please share your thoughts about the education of engineering/computing students regarding ethical issues and societal impacts" and six (three from Case A and three from Case B) mentioned the importance of ESI. An educator at Case A noted, "Fundamentally, an engineer must take into consideration both ethical issues and societal impacts to be a valuable member of society." An educator at Case B also emphasizes this responsibility since "issue[s] such as climate change are very important for the future of humanity. All students need to become very sensitive to these issues." These comments allude to the macroethical responsibility of engineers to society and the importance of fostering that sense of responsibility in engineering curricula.

One potential threat to validity in the survey results is social desirability bias, the tendency to overreport desirable attributes instead of reporting true feelings [40]. This bias is important to consider in research of sensitive topics, such as ethics [41]. It is unclear what role, if any, social desirability bias played for each case. In addition, if leverage of the topic impacted the low response rate from Case B, the respondents may not be broadly representative of the opinions of other faculty in the department. The number of 'active nonrespondents' for Case B (7 individuals who did not consent, opened the survey but did not answer any questions, or opted out of the survey; [27]) versus none from Case A where the results represent 68% of the department faculty somewhat seems to support this concern.

Document analysis of the educational objectives was employed to explore if faculty members' perceptions of importance were reflected formally by the department. Case A has six educational objectives including students being ethical and embracing safety as two stand-alone objectives. Case B has five objectives, including high ethical standards, which was coupled with another professional outcome.

The undergraduate curriculum and course descriptions for each department based on the catalog were also analyzed. At Case A, ESI was mentioned in the description of a required sophomore-level course that covered contemporary issues and societal context. Although interviews with multiple faculty members at Case A discussed the coverage of ESI in capstone design, ESI was not explicit in its catalog course description. At the college level, capstone design across all engineering programs was described to include economic, societal, and global context, which alludes to macroethical integration. At Case B, ethics and professional responsibility were included in the course description for an introductory course. The course website for senior design at Case B noted the expectation that projects are ethical and safe. The senior design course site also had a section dedicated to ethical guidelines. Both programs required 128 credits for graduation but only appeared to explicitly cover ESI in one required three-credit course. However, the descriptions in the catalogs were very short (median of 45 and 20 words for Case A and B, respectively) and future work could explore course syllabi and ABET self-study reports to glean a more complete understanding of course content, similar to the approach taken by Barry and Ohland [42].

V. Conclusion

The engineering profession necessitates an understanding of ethical responsibility and societal context to "hold paramount the safety, health, and welfare of the public" [43]. Since engineering faculty play a key role in the integration of ESI in the curriculum, it is important to understand influences on their instructional perspectives. This exploratory study was grounded in a case study methodology to examine educators' perceptions of the influence of academic environment on ESI education. Survey results indicated similar perceptions of college and institution culture at both cases, which were corroborated with document analysis. Interview data indicated strong support at the college level for Case A while interviewees at Case B did not specifically discuss this influence. The department climate and leadership appeared to have acute effects on faculty members' perceptions of support and suggested the point at which the two cases diverged. A greater portion of faculty at Case A were believed to engage in ESI instruction creating an engaged culture that was bolstered by a supportive department head.

Survey respondents from both departments ascribed high importance to teaching ethics and the societal impacts of engineering and technology. On average, educators considered ESI of equal importance as math, science, and engineering content. However, these findings may not represent the majority of faculty in the department for Case B, given the low survey response rate. The interviews illuminated nuances to these perceptions of importance such as the need to develop ethical awareness and reasoning skills, meet accreditation criteria, integrate technical material and its broader impacts, and convey the societal responsibility of the profession. However, document analysis of the curriculum and course descriptions from the catalog revealed that ESI was explicitly included in very few required courses in both departments.

A. *Implications*

This case study research knits together multiple pieces of evidence to explore the influence of environment on engineering faculty relative to ESI education. This study found, consistent with [38], that a culture supportive of ESI education should be balanced from bottom-up and top-down approaches. As discussed by participants in Case A, establishing a critical mass of faculty who value and engage in ESI instruction fosters a climate of support for those educators and broadens students' exposure to these topics across the curriculum. On the other hand, participants in Case B noted the connection between limited faculty support and minimal integration of ESI in the curriculum due to this resistance. The survey and interview data also indicated explicit directives from leadership can help facilitate this integration, especially at the department level.

The academic environment is also just one of many influences on faculty members and their teaching. Future research could explore structural and cultural variables such as teaching load, research expectation, and faculty composition, and how they affect faculty members' perception of the environment and their instructional practices within it. Disciplinary effects could also be isolated by using a case study methodology with departments of the same disciplines at different institutions.

With increasing attention paid to the inclusion of ESI and growing responsibility on engineering faculty, it is important to acknowledge the environment in which faculty develop their instructional practices and perspectives. This consideration mirrors the emerging trend of conceptualizing ethics macroethically instead of microethically [2], [44]. Framing ethics individualistically with an emphasis on the role and autonomy of engineers averts attention from the broader context [12]. Engineers do not make decisions regarding ethics in a vacuum and nor do engineering educators. An understanding of context and culture and how their influences percolate into the teaching of individual faculty can facilitate reflection on the role of the environment and how it can be shaped to support ESI education and educators. This in turn will develop students' exposure and competence related to ethical and societal issues, which is essential for confronting the complex and convergent challenges facing the engineering profession.

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REFERENCES

[1] National Academy of Engineering, *Infusing Ethics into the Development of Engineers: Exemplary Education Activities and Programs*. 2016. doi: 10.17226/21889.

[2] J. R. Herkert, "Ways of thinking about and teaching ethical problem solving: Microethics and macroethics in engineering," *SCI ENG ETHICS*, vol. 11, no. 3, pp. 373–385, Sep. 2005, doi: 10.1007/s11948-005-0006-3.

[3] ABET, "Criteria for Accrediting Engineering Programs, 2019 – 2020 | ABET," 2018. https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/ (accessed Jan. 14, 2021).

[4] M. W. Peterson and M. G. Spencer, "Understanding academic culture and climate," *New Directions for Institutional Research*, vol. 1990, no. 68, pp. 3–18, 1990, doi: 10.1002/ir.37019906803.

[5] B. E. Barry and M. W. Ohland, "Applied Ethics in the Engineering, Health, Business, and Law Professions: A Comparison," *Journal of Engineering Education*, vol. 98, no. 4, pp. 377–388, 2009, doi: 10.1002/j.2168-9830.2009.tb01034.x.

[6] R. E. McGinn, "'Mind the gaps': An empirical approach to engineering ethics, 1997–2001," *SCI ENG ETHICS*, vol. 9, no. 4, pp. 517–542, Dec. 2003, doi: 10.1007/s11948-003-0048-3.

[7] S. D. Sheppard, K. Macatangay, A. Colby, and W. M. Sullivan, *Educating Engineers: Designing for the Future of the Field. Book Highlights*. Carnegie Foundation for the Advancement of Teaching, 2008. Accessed: May 07, 2021. [Online]. Available: https://eric.ed.gov/?id=ED504076

[8] A. Colby and W. M. Sullivan, "Ethics Teaching in Undergraduate Engineering Education," *Journal of Engineering Education*, vol. 97, no. 3, pp. 327–338, 2008, doi: https://doi.org/10.1002/j.2168-9830.2008.tb00982.x.

[9] J. R. Herkert, "Engineering ethics education in the USA: Content, pedagogy and curriculum," *European Journal of Engineering Education*, vol. 25, no. 4, pp. 303–313, Dec. 2000, doi: 10.1080/03043790050200340.

[10] J. L. Hess and G. Fore, "A Systematic Literature Review of US Engineering Ethics Interventions," *Sci Eng Ethics*, vol. 24, no. 2, pp. 551–583, Apr. 2018, doi: 10.1007/s11948-017-9910-6.

[11] D. R. Haws, "Ethics Instruction in Engineering Education: A (Mini) Meta-Analysis," *Journal of Engineering Education*, vol. 90, no. 2, pp. 223–229, 2001, doi: https://doi.org/10.1002/j.2168-9830.2001.tb00596.x.

[12] E. Conlon and H. Zandvoort, "Broadening Ethics Teaching in Engineering: Beyond the Individualistic Approach," *Sci Eng Ethics*, vol. 17, no. 2, pp. 217–232, Jun. 2011, doi: 10.1007/s11948-010-9205-7.

[13] J. A. Cruz and W. J. Frey, "An effective strategy for integrating ethics across the curriculum in engineering: An ABET 2000 challenge," *SCI ENG ETHICS*, vol. 9, no. 4, pp. 543–568, Dec. 2003, doi: 10.1007/s11948-003-0049-2.

[14] J. Li and S. Fu, "A Systematic Approach to Engineering Ethics Education," *Sci Eng Ethics*, vol. 18, no. 2, pp. 339–349, Jun. 2012, doi: 10.1007/s11948-010-9249-8.

[15] A. R. Bielefeldt, M. Polmear, D. Knight, C. Swan, and N. Canney, "Intersections between Engineering Ethics and Diversity Issues in Engineering Education," *J. Prof. Issues Eng. Educ. Pract.*, vol. 144, no. 2, p. 04017017, Apr. 2018, doi: 10.1061/(ASCE)EI.1943-5541.0000360.

[16] A. R. Bielefeldt, M. Polmear, D. Knight, N. Canney, and C. Swan, "Disciplinary Variations in Ethics and Societal Impact Topics Taught in Courses for Engineering Students," *J. Prof. Issues Eng. Educ. Pract.*, vol. 145, no. 4, p. 04019007, Oct. 2019, doi: 10.1061/(ASCE)EI.1943-5541.0000415.

[17] M. Polmear, A. Bielefeldt, D. Knight, C. Swan, and N. Canney, "Faculty Perceptions of Challenges to Educating Engineering and Computing Students About Ethics and Societal Impacts," in *2018 ASEE Annual Conference & Exposition Proceedings*, Salt Lake City, Utah, Jun. 2018, p. 30510. doi: 10.18260/1-2--30510.

[18] H. M. Matusovich, R. A. Streveler, and R. L. Miller, "Why Do Students Choose Engineering? A Qualitative, Longitudinal Investigation of Students' Motivational Values," *Journal of Engineering Education*, vol. 99, no. 4, pp. 289–303, 2010, doi: https://doi.org/10.1002/j.2168-9830.2010.tb01064.x.

[19] R. K. Yin, *Case Study Research: Design and Methods*. SAGE, 2003.

[20] C. Noy, "Sampling Knowledge: The Hermeneutics of Snowball Sampling in Qualitative Research," *International Journal of Social Research Methodology*, vol. 11, no. 4, pp. 327–344, Oct. 2008, doi: 10.1080/13645570701401305.

[21] J. W. Creswell, *Qualitative inquiry and research design: Choosing among five approaches, 2nd ed*. Thousand Oaks, CA, US: Sage Publications, Inc, 2007, pp. xvii, 395.

[22] A. Bielefeldt, N. Canney, C. Swan, and D. Knight, "Efficacy of Macroethics Education in Engineering," in *2016 ASEE Annual Conference & Exposition Proceedings*, New Orleans, Louisiana, Jun. 2016, p. 26919. doi: 10.18260/p.26919.

[23] L. Romkey, "Engineering, Society, and the Environment in the Teaching Goals and Practices of Engineering Instructors," in *2015 ASEE Annual Conference and Exposition Proceedings*, Seattle, Washington, Jun. 2015, p. 26.650.1-26.650.25. doi: 10.18260/p.23988.

[24] A. Katz and D. Knight, "Factors Related to Faculty Views Toward Undergraduate Engineering Ethics Education," in *2017 ASEE Annual Conference & Exposition Proceedings*, Columbus, Ohio, Jun. 2017, p. 28350. doi: 10.18260/1-2--28350.

[25] O. Pierrakos *et al.*, "Faculty Survey on Learning Through Service: Development and Initial Findings," in *2012 ASEE Annual Conference & Exposition Proceedings*, San Antonio, Texas, Jun. 2012, p. 25.635.1-25.635.22. doi: 10.18260/1-2--21392.

[26] R. M. Groves, S. Presser, and S. Dipko, "The Role of Topic Interest in Survey Participation Decisions," *Public Opinion Quarterly*, vol. 68, no. 1, pp. 2–31, Mar. 2004, doi: 10.1093/poq/nfh002.

[27] J. R. B. Halbesleben and M. V. Whitman, "Evaluating Survey Quality in Health Services Research: A Decision Framework for Assessing Nonresponse Bias," *Health Serv Res*, vol. 48, no. 3, pp. 913–930, Jun. 2013, doi: 10.1111/1475-6773.12002.

[28] S. Lippmann, T. Frese, K. Herrmann, K. Scheller, and H. Sandholzer, "Primary care research - trade-off between representativeness and response rate of GP teachers for undergraduates," *Swiss Med Wkly*, Mar. 2012, doi: 10.4414/smw.2012.13537.

[29] G. A. Bowen, "Document Analysis as a Qualitative Research Method," *Qualitative Research Journal*, vol. 9, no. 2, pp. 27–40, Jan. 2009, doi: 10.3316/QRJ0902027.

[30] Glaser, "The Constant Comparative Method of Qualitative Analysis," p. 11, 1965.

[31] R. S. Barbour, "Checklists for improving rigour in qualitative research: a case of the tail wagging the dog?," *BMJ*, vol. 322, no. 7294, pp. 1115–1117, May 2001, doi: 10.1136/bmj.322.7294.1115.

[32] N. Salkind, *Encyclopedia of Research Design*. Thousand Oaks, California, 2010. doi: 10.4135/9781412961288.

[33] N. Nachar, "The Mann-Whitney U: A Test for Assessing Whether Two Independent Samples Come from the Same Distribution," *TQMP*, vol. 4, no. 1, pp. 13–20, Mar. 2008, doi: 10.20982/tqmp.04.1.p013.

[34] E. Godfrey, "Understanding disciplinary cultures: The first step to cultural change.," in *Cambridge Handbook of Engineering Education Research*, Cambridge University Press, 2014.

[35] AIChE, "Code of Ethics," Mar. 09, 2012. /about/governance/policies/code-ethics (accessed May 02, 2021).

[36] IEEE, "IEEE Code of Ethics." https://www.ieee.org/about/corporate/governance/p7-8.html (accessed May 02, 2021).

[37] Y. Dodge, *The Concise Encyclopedia of Statistics*. New York: Springer-Verlag, 2008. Accessed: May 02, 2021. [Online]. Available: https://www.springer.com/gp/book/9780387328331

[38] C. Meyers, "Institutional culture and individual behavior: Creating an ethical environment," *SCI ENG ETHICS*, vol. 10, no. 2, pp. 269–276, Jun. 2004, doi: 10.1007/s11948-004-0022-8.

[39] C. C. Morphew and M. Hartley, "Mission Statements: A Thematic Analysis of Rhetoric Across Institutional Type," *The Journal of Higher Education*, vol. 77, no. 3, pp. 456–471, 2006, doi: 10.1353/jhe.2006.0025.

[40] P. Grimm, "Social Desirability Bias," in *Wiley International Encyclopedia of Marketing*, American Cancer Society, 2010. doi: 10.1002/9781444316568.wiem02057.

[41] D. M. Randall and M. E. Fernandes, "The social desirability response bias in ethics research," p. 13.

[42] B. E. Barry and M. W. Ohland, "ABET Criterion 3.f: How Much Curriculum Content is Enough?," *Sci Eng Ethics*, vol. 18, no. 2, pp. 369–392, Jun. 2012, doi: 10.1007/s11948-011-9255-5.

[43] National Society of Professional Engineers, "Code of Ethics for Engineers." National Society of Professional Engineers, 2019. [Online]. Available: https://www.nspe.org/sites/default/files/resources/pdfs/Ethics/CodeofEthics/NSPECodeofEthicsforEngineers.pdf

[44] H. Zandvoort, I. VanDePoel, and M. Brumsen, "Ethics in the engineering curricula: Topics, trends and challenges for the future," *European Journal of Engineering Education*, vol. 25, no. 4, pp. 291–302, Dec. 2000, doi: 10.1080/03043790050200331.