

Measuring Ethical Development of Engineering Students Across Universities and Class Years

ABSTRACT

While the technical aspects of engineering are emphasized in education and industry, the ethical aspects are, in some ways, just as vital. Engineering instructors should teach undergraduates about their ethical responsibilities in the realm of engineering. Students would then be more likely to grasp their responsibilities as professionals. For many students, undergraduate study is a time of growth and change, with their ethical development just beginning to take shape. In this study, we aim to understand the progression of ethical development for engineering undergraduate students and identify key factors that may contribute to their development. To help us assess ethical development, we deployed in Fall 2020 a survey to undergraduate engineering students at two universities; the survey entailed the Defining Issues Test-2 (DIT-2). The DIT-2 evaluates ethical development based on Kohlberg's theory of moral development; the test recognizes three levels of morality—preconventional, conventional, and postconventional. This study evaluates the associations between students' university and class year and their Personal Interest, Maintaining Norms, and N2 scores. We utilized the results of a multivariate analysis of variance (MANOVA) to address the following research question: *Is a student's ethical development associated with their university and class year?* The results of the analysis reveal that students' ethical development appear to differ between universities and to lie along a continuum, changing from first-year students to seniors of engineering undergraduate study.

Keywords: Engineering Ethics, Undergraduate, DIT, Education, Ethical Development

INTRODUCTION

While the fields of education and industry tend to emphasize the technical aspects of engineering, its ethical aspects also have significant impacts. Most engineering work cannot be separated from the social systems it directly impacts. Indeed, all communities are impacted in important ways by bridges, water systems, computer networks, and engineered gadgets. In the event of a vehicle collision, for instance, engineers have already played an essential role in ensuring occupant safety by helping to mitigate injury through crash detection, seatbelt design, and airbag response (Lindquist et al., 2003). However, car crash testing historically uses data based on the average male body size, leaving many people who don't fit this description, namely women, at great risk of injury or death (Linder & Svensson, 2019). In this example, and many other engineering design practices, public safety is better ensured when engineers possess a well-rounded ethical understanding of their role in helping ensure it. When engineers lack an awareness of broader ethical responsibilities, diverse design perspectives, and inclusive hiring practices, they can inadvertently impose negative consequences on some populations.

Many engineering professional societies maintain Codes of Ethics, to which their members are expected to adhere (e.g. ASCE, NSPE, IEEE). The top priority of most codes is the requirement to "hold paramount the safety, health, and welfare of the public" (NSPE, 2019). As the engineering industry has grown and these codes have been revised over time, many of them now address issues of sustainability and diversity. The American Society of Mechanical Engineers states that "engineers shall consider environmental impact" while the Institute of Electrical and Electronics Engineers further states that engineers shall "strive to comply with ethical design and sustainable development practices" (ASME, 2012; IEEE, 2020). The American Society of Civil Engineers revised their code in 2020 to emphasize the importance of considering stakeholders in engineering

ethics. The code now states that engineers shall “recognize the diverse historical, social, and cultural needs of the community, and incorporate these considerations in their work” (ASCE, 2020). These code revisions demonstrate the changing environment of the engineering industry and new areas of focus for engineering ethics. Educators and industry observers increasingly recognize it as important that engineers learn and practice ethical considerations and that engineering students should study them.

Undergraduate study is, for many students, a time of growth, development, and change, as it is a transition period between high school (where many decisions are made for them) and professional work (where they need to think for themselves and make their own decisions; Gall et al., 2000). how students develop during this time can be influenced by many factors, including both biological changes (e.g., cognitive development) and environmental factors (e.g., social interactions). College-age students are in a period of cognitive and emotional development, which likely has a great impact on their ability to develop ethical understanding (Gerson & Neilson, 2014). Additionally, their courses, extracurricular activities, internships, and other experiences allow for opportunities to question and improve their ethical understanding. The fact that these students are still developing cognitively and emotionally suggests a need to observe changes in their ethical development as they progress through their undergraduate education.

In undergraduate engineering education, the Accreditation Board for Engineering and Technology (ABET) provides guidance on curriculum. Regarding engineering ethics, ABET requires that students acquire “an ability to recognize ethical and professional responsibilities [...] in global, economic, environmental, and societal contexts” (ABET, 2021). Yet while these are worthy objectives for engineering education, it is unclear if these goals are being reached. In fact, some researchers argue that as students become socialized through education, internships,

research, and jobs, they tend to concern themselves less with social issues and more with technical ones (Cech, 2014). Other researchers argue that these extracurricular experiences expose students to diverse perspectives, leading to a more expansive perspective on ethical responsibilities (Burt et al., 2013; Carpenter et al., 2014). This discrepancy demonstrates the need for further investigation into engineering students' ethical development and the initiatives taken by universities to encourage socialization.

In this study, we aim to understand the progression of ethical development for engineering undergraduate students and identify key factors that may contribute to their development. In Fall 2020, we deployed a web-based survey to undergraduate students at two universities; to help us assess their ethical development, we used the Defining Issues Test-2 (DIT-2; Rest et al., 1999). We utilized the results of this test to address the following research question: *Is a student's ethical development associated with their university and class year?* We also observed differences in the engineering ethics curriculum between the two universities. We initially hypothesized the following:

***H1.** DIT-2 scores differ significantly between the two universities.*

***H2.** DIT-2 scores differ significantly between first-year students and senior students.*

BACKGROUND

The study of engineering ethics is based on a foundation of philosophy, law, behavioral sciences, history, and religious studies (Weil, 1984). As engineering technologies have grown, so have questions and concerns about ethics. As technology has advanced and the world's economy become more globalized, for instance, researchers in computer and electrical engineering have had to expand their commitment to protecting consumer's privacy and security (Gürses & del Alamo, 2016; Shilton et al., 2020). Additionally, engineering ethics varies across disciplines within

engineering. For instance, biomedical and mechanical engineering ethics research tends to focus on responsible conduct of research (DuBois et al., 2010; Keefer et al., 2014), likely due to the human research component of much of this work. Civil and environmental engineering ethics research often focuses on social systems and community impacts of infrastructure (Chance et al., 2021; El-Zein et al., 2008). Alternatively, many engineering ethics studies evaluate the motivations behind academic dishonesty at both the high school (Sisti, 2007) and college levels. The studies focused on cheating at the college level span many disciplines, including business (Simkin & McLeod, 2010), humanities (Harding et al., 2007), and engineering (Carpenter et al., 2010).

Many survey tools can be used to evaluate ethical development, including the Perceptions and Attitudes toward Cheating among Engineering Students surveys (PACES), the Moral Judgement Test (MJT), the DIT, and the Engineering and Science Issues Test (ESIT). The Perceptions and Attitudes toward Cheating among Engineering Students (PACES) surveys, which focus on issues of academic dishonesty, were developed to evaluate perceptions and rates of cheating in student populations (Bielefeldt, 2009). Studies use the PACES-1 survey primarily to evaluate student perceptions and definitions of academic dishonesty (Bielefeldt, 2009; Finelli et al., 2007) while the PACES-2 survey is used to evaluate a theoretical model of ethical decision-making in cheating (Harding et al., 2012; Smith et al., 2016).

Several ethics survey tools are based on the theoretical framework of Kohlberg's theory of moral development and have been developed and revised over time. The Moral Judgement Test (MJT) is based on Kohlberg's Moral Judgement Interview and is often utilized in non-engineering contexts, such as business and management (Ishida, 2006; Lind, 2005). The Defining Issues Test (DIT) is similarly based on the stages of Kohlberg's theory of moral development, and allows for an analysis of ethical development in survey respondents (e.g. Ishida, 2006; Self & Ellison, 1998).

The DIT was revised over time to better align with modern societal perspectives and events, allowing for better evaluation using the DIT-2 (e.g., Hamlin et al., 2015; Harding et al., 2012).

Kohlberg’s theory of moral development—the theoretical foundation used in this study—describes the stages of ethical development that one progresses through over time, typically during childhood and adolescence (Kohlberg, 1981). These stages are divided into the following three levels: preconventional, conventional, and postconventional. Kohlberg’s theory of moral development tells us that people transition from one stage of moral reasoning to another through their experiences and development as they age (Rest et al., 1999). Students experience many changes through adolescence and young adulthood, including working for the first time, moving away from home, and making friends from diverse backgrounds. These varied experiences can encourage ethical development, allowing students, throughout their college years, to move from preconventional to postconventional.

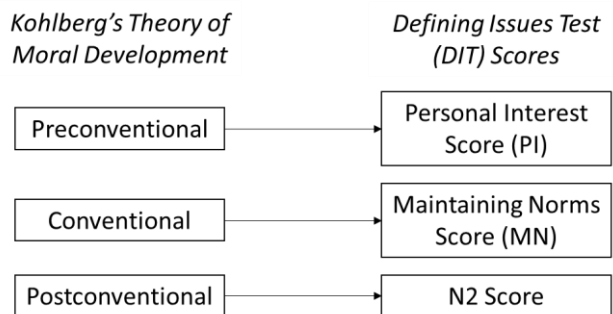


Figure 1: Kohlberg’s theory of moral development (Rest et al., 1999) mapped to DIT-2 scores.

The Defining Issues Test (DIT-2) is used to observe the moral reasoning of participants and assign numerical values to the levels of Kohlberg’s stages (Rest et al., 1999). The DIT-2 consists of six moral dilemmas (or in modified shortened versions, as with the one used in this study, three) where the respondent is asked to evaluate the actions that the protagonist should take in each scenario. Among the scores produced by this test, three are of interest to this study, each

aligning with one level of Kohlberg's theory of moral development—Personal Interest (PI), Maintaining Norms (MN), and N2 Score (see Figure 1).

The Personal Interest (PI) score aligns with Kohlberg's Preconventional stage, in which people are most concerned with self-interest and avoiding consequences for poor behavior (van den Enden et al., 2019). The PI score indicates a tendency to focus on issues that impact oneself (Thoma, 2006). In engineering education, this might present in a student who is highly focused on their own test scores and achievements that they can put on a resume. While not unreasonable, focus just on personal interest might cause a student to avoid helping others who are struggling with a homework assignment or to fail to be a team player in group assignments. As professionals, engineers with high PI scores might strive to perform their best in front of a boss, leading to promotions and career opportunities, but these engineers may also be difficult to work with when compromises are necessary in team settings. Alternatively, those engineers who have lower PI scores, and are therefore not just personally interested, might be more supportive and encouraging of coworkers.

The Maintaining Norms (MN) score represents the Conventional Morality level. A person at this level is concerned with following rules to uphold the social order and to be seen as a good person to others (Thoma, 2006; van den Enden et al., 2019). People who earn a high MN score are likely to value respecting authority and will often agree with the values of those around them (Marshall et al., 2017). High MN scores are valuable in engineering as this can translate to working well in groups, a skill that is essential in engineering work. Additionally, high MN scores can lead engineers to a commitment of upholding standards and following rules, which is important in safe design practices. As a distinction from the preconventional morality level, this commitment shows a dedication to others' wellbeing. However, a focus on maintaining norms might hinder one from

thinking innovatively and independently, as such a focus tends to cause individuals to unquestioningly follow proven methods and accept directives.

The N2 score is a combination score that represents the extent to which an individual engages in postconventional thinking while avoiding preconventional thinking (Harding et al., 2012). Individuals who earn a higher N2 score are more likely to think critically about their moral principles and develop their own moral judgments, rather than just adopting the principles of those around them or acting out of self-interest. People in the Postconventional stage are concerned with developing their own sense of right and wrong, based upon principles of consensus and social contract, as well as questioning existing norms and traditions (Marshall et al., 2017; van den Enden et al., 2019). This can contribute in important ways to engineering, for design work indeed impacts social systems. An engineer with a tendency toward postconventional morality might be more inclined to consider the social impact of their work, and question traditional practices that might be harmful but overlooked. Alternatively, a tendency toward postconventional thinking might make traditional work structures challenging, if engineers are expected to follow procedures without question.

We depart from the existing literature by evaluating these three resulting scores of the DIT-2—Personal Interest (PI), Maintaining Norms (MN), and N2 score. Other studies have focused solely on the N2 score (Emler et al., 2007) or analyze the N2 in combination with the consolidation/transition metric (Harding et al., 2012). Rather, here we use the three scores that each represent a level of morality in Kohlberg’s theory of moral development, as shown in Figure 1. Observing the three levels of morality allows us to evaluate differences between engineering class years. As such, we can observe the shifts in ethical development between the beginning of engineering study, as a first-year student, and the end, as a graduating senior. This evaluation

further allows us to explore factors that might impact this moral development in students, including coursework and diverse learning environments.

DATA & METHODS

Figure 2 shows the research process used in this study. In Fall 2020, we deployed a web-based survey to undergraduate engineering students at two public universities, University A (located in the Southern United States) and University B (located in the Midwestern United States). The survey reached students across all engineering disciplines and class years, resulting in 500 valid responses, as shown in Table 1. The survey was administered through the Qualtrics Survey Software (Qualtrics, 2020) after undergraduate and graduate civil engineering students pilot-tested it to check for accessibility and clarity; their responses are not included in the final sample. The survey included two components that are relevant to this study, the Defining Issues Test (DIT-2) and a range of sociodemographic questions.

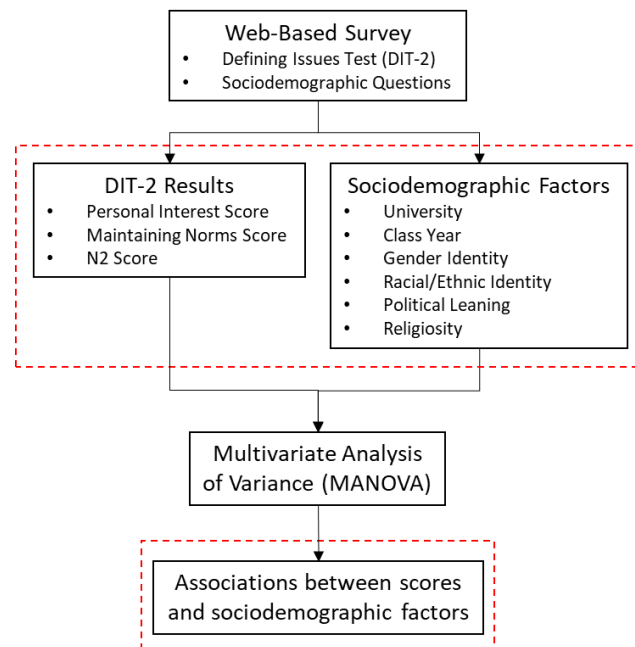


Figure 2. Research process used to evaluate associations between ethical development and sociodemographic factors; red dotted-line boxes indicate data and results.

For this study, we used the DIT-2 evaluation, which included three stories detailing ethical dilemmas. After reading each ethical dilemma, survey respondents were asked about the challenges the protagonists faced in each story. Survey responses were sent to the Center for the Study of Ethical Development at the University of Alabama for evaluation (Center for the Study of Ethical Development, 2019). Numeric scores were given to each respondent based on their responses. Here, we use three scores: Personal Interest (PI), Maintaining Norms (MN), and N2 score. Each of these scores are correlated with Kohlberg's stages of moral development, as shown in Figure 1 (Center for the Study of Ethical Development, 2019).

Table 1. Number of survey respondents by university and class year

Parameter	Count	Percentage
<i>University A</i>	152	30%
<i>University B</i>	348	70%
<i>First-year</i>	141	28%
<i>Sophomore</i>	118	24%
<i>Junior</i>	130	26%
<i>Senior</i>	111	22%

The sociodemographic questions included multiple choice responses, including a “prefer not to respond” option, with approximately 25 questions relating to students’ backgrounds. To test our hypotheses, we use class year and university for the independent variables. Following existing literature, we use four sociodemographic factors as control variables: gender identity (Becker & Ulstad, 2007), racial/ethnic identity (Moreland & Leach, 2001), political leaning (Gross, 1996), and religiosity (Cottone et al., 2007). Regarding gender identity, respondents could identify as a gender identity other than man or woman in the survey; however, these other gender identities were not present at high enough frequencies to include in the statistical analysis.

To evaluate the hypotheses, we analyzed survey results to find associations between DIT scores and sociodemographic factors. The respondents' DIT scores served as dependent variables. The first step in analysis was a multivariate factorial analysis of variance (MANOVA), where we tested all variables as a group. MANOVA allows for the testing of multiple dependent variables at once—i.e., multiple DIT scores, and tests for the difference in two or more vectors of means (Haase & Ellis, 1987). An artificial dependent variable was constructed to represent the group of dependent variables as a linear combination of the measured dependent variables (Ramsey et al., 2017). The MANOVA showed that, using a significance level of 10%, each independent variable was significant, either by main or interaction effects. Upon finding significant main and interaction effects, we performed post-hoc tests using univariate factorial analysis of variance (ANOVA) and pairwise comparisons.

RESULTS

Table 2 shows the mean DIT-2 scores and standard deviations for respondents by university and class year. As discussed above, the Personal Interest (PI) score represents the pre-conventional stage and the Maintaining Norms (MN) score represents the conventional stage. The N2 score represents the postconventional stage, with consideration of the tendency to avoid preconventional thinking (Rest et al., 1999; Thoma, 2006).

Table 2: Summary statistics of DIT-2 scores for independent variables: universities and class years

	Personal Interest		Maintaining Norms		N2 Score	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
University						
<i>University A</i>	27.13	16.73	23.20	14.32	40.00	14.35
<i>University B</i>	29.66	15.16	28.09	14.31	33.63	13.60
Class Year						
<i>First-Year</i>	30.26	14.87	26.95	14.08	33.90	13.55
<i>Sophomore</i>	30.62	16.38	26.07	13.02	34.73	13.88
<i>Junior</i>	28.62	16.42	27.62	15.98	35.42	14.00
<i>Senior</i>	25.63	14.71	25.54	14.66	38.74	14.91

232 The MANOVA results, which looked at the three DIT-2 scores as a whole and are shown
 233 in Table 3, showed that university and class year had significant interaction effects ($p = 0.018$).
 234 Using this information, we then used ANOVA to probe each of the three DIT-2 scores. The
 235 ANOVA on the Personal Interest (PI) score resulted in significant main effects for both university
 236 ($p = 0.088$) and class year ($p = 0.058$). Table 2 shows that University B has a higher mean PI score
 237 than University A (29.66 and 27.13). Additionally, first-year and sophomore students have
 238 significantly higher PI scores than senior students ($p = 0.092$ and $p = 0.075$; see Table S2 in
 239 Supplemental Information). The ANOVA on the Maintaining Norms (MN) score resulted in
 240 significant interaction effects for university and class year ($p = 0.080$; see Table S3). Sophomore
 241 students at University B received higher MN scores than sophomores at University A (27.75 and
 242 22.93; $p = 0.055$). Similarly, senior students at University B received higher MN scores than
 243 seniors at University A (28.95 and 18.43; $p = 0.0003$). The ANOVA on the N2 score resulted in
 244 significant main effects for both university and class year ($p = 9.24e-07$; 0.047). University A
 245 received a higher mean N2 score than University B (40.00 and 33.63). Senior students earned
 246 significantly higher N2 scores than first-year students (38.74 and 33.90; $p = 0.034$).

247 Table 3. Results of multivariate factor analysis of variance (MANOVA)

	Df	Pillai	approx F	num Df	den Df	Pr(> F)	sig
<i>Independent Variables</i>							
University	1	0.063	10.499	3	472	1.07E-06	***
Class Year	3	0.026	1.381	9	1422	0.192	
University: Class Year	3	0.042	2.233	9	1422	0.018	*
<i>Control Variables</i>							
Political Leaning	4	0.146	6.060	12	1422	1.93E-10	***
Religiosity	4	0.047	1.895	12	1422	0.031	*
Gender Identity	1	0.042	6.852	3	472	1.59E-04	***
Race/Ethnicity	1	0.011	1.788	3	472	0.149	
Political Leaning: Gender Identity	4	0.050	1.994	12	1422	0.022	*
Political Leaning: Race/Ethnicity	3	0.031	1.659	9	1422	0.094	.
Gender Identity: Race/Ethnicity	1	0.017	2.795	3	472	0.040	*

Residuals: 474

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

DISCUSSION

Differences Between Universities

In support of Hypothesis 1, the ANOVA tests revealed that there is a significant difference between the two universities for all three DIT-2 scores (PI $p = 0.088$, MN $p = 1.6E-04$, N2 $p = 9.2E-07$). The students at University A (located in the Southern United States) scored lower relative to the students attending University B (located in the Midwestern United States) for both the Personal Interest (PI) and Maintaining Norms (MN) scores, and scored higher for the N2 score. According to Kohlberg's theory of moral development, a higher N2 score indicates ethical development at the postconventional level. At this level, individuals develop their own moral judgements, rather than, as in the earlier stages, deferring to existing norms or acting just out of self-interest (Emler et al., 2007). Reaching this stage of development demonstrates that a person can synthesize and critically evaluate information relevant to moral decisions, which is especially relevant to engineering settings where there are many inputs and potential impacts of work.

Many different factors can influence the discrepancy between the N2 scores of the two universities. While the correlations that we explore here are not necessarily the cause of the differences, it is helpful to explore potential factors. First, we explored the civil engineering curriculum at each university and identified key differences. We chose to observe civil engineering due to the high number of respondents in this major (10%) as well as the availability of data to the researchers. Additionally, civil engineering often focuses on public works that have broad societal impacts. In fact, the American Society of Civil Engineers Code of Ethics states that the highest priority of civil engineers must be its responsibilities to society (ASCE, 2020). This focus on societal impacts in civil engineering projects and coursework is important because it helps shed light on students' observed levels of morality.

The Accreditation Board for Engineering and Technology (ABET) provides guidance on required learning outcomes for engineering students. While accredited engineering programs must meet these learning outcomes, they have freedom to implement the lessons in ways they see fit. Therefore, engineering curriculums can vary between universities. Table 4 includes the civil engineering coursework at both universities observed in this study. The courses listed here fulfill either Student Outcome 2 or Student Outcome 4 according to ABET standards. We focus on SO2 and SO4 in this study, listed below, because they each include issues relating to ethics and societal perspectives (ABET, 2021).

Student Outcome 2: an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

Student Outcome 4: an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

Table 4. Civil engineering courses and ABET outcomes at each university

	Level	Topic	SO2	SO4
University A	Advanced	Systems		X
	Advanced	Statistics	X	X
	Advanced	Fluids		X
	Advanced	Transportation		X
	Advanced	Materials	X	
	Advanced	Environmental		X
	Advanced	Water Resources	X	X
	Advanced	Geotechnical	X	X
	Advanced	Professionalism	X	X
	Advanced	Communication		X
University B	Fundamental	Civil Engineering		X
	Fundamental	Engineering Economics		X
	Advanced	Structural Engineering	X	
	Advanced	Transportation		X
	Advanced	Water Resources	X	
	Advanced	Transportation	X	
	Advanced	Geotechnical	X	
	Advanced	Capstone Design		X

As shown in Table 4, University A, at which students had higher N2 scores on average, includes more classes in the civil engineering curriculum which fulfill these ABET outcomes. In fact, SO4, which explicitly includes an ethics requirement, appears to be applicable for almost every sub-discipline's higher-level course at University A, whereas at University B this is only the case for the transportation course. It is possible that incorporating this requirement into more classes at University A has provided students opportunities to learn and apply ethics to their engineering lessons. This result suggests that, in order to improve students' ethical development, University B might consider further integrating ethics into advanced-level engineering courses. While this anecdotal example of two civil engineering departments is limited, it does provide valuable insight into how engineering departments might make changes in order to improve students' ethical development. This comparison could be beneficial for other engineering disciplines and universities. For instance, studies show that environmental engineering courses tend to include more ethics lessons in their classes than other engineering disciplines (Bielefeldt et al., 2018). Future research could compare different engineering disciplines to further evaluate the impact of curriculum on ethical development.

Differences Between Class Years

The analyses performed in this study reveal that senior engineering students earn a lower Personal Interest (PI) score than first-year students ($p = 0.092$), with the inverse being true for the N2 score, which measures postconventional thinking ($p = 0.035$). According to Kohlberg's theory of moral development, individuals can progress from the preconventional level (PI score) to the postconventional level (N2 score) as they learn, grow, and age (Kohlberg, 1981). We use these scores to better understand the changes and influences on students as they progress from their first year through graduation.

Another helpful framework in understanding students' growth is the Chickering Model of Student Development. This model includes characteristics of development that change throughout college years, including competence, identity, integrity, and others (Ambrose et al., 2010; Chickering, 1969). Similar to Kohlberg's theory of moral development, many intellectual development models include a stage of development characterized by an understanding of "right vs. wrong" and often a transformation from dualistic thinking to multiplicity (Ambrose et al., 2010; Baxter Magolda, 1992; Belenky et al., 1986; Perry, 1999). These models demonstrate that the intellectual changes occurring throughout college contribute to moral development, justifying the difference in scores between first-year students and seniors in this study.

Another important aspect of students' development throughout an undergraduate education is social identity development (Ambrose et al., 2010; Erikson, 1950; Marcia, 1966). As students progress through college, they often question their previously held beliefs and identities and develop a greater understanding of their personal identity (Hardiman & Jackson, 1992). Similar to Kohlberg's theory of moral development, students progress through the stages of development as they question beliefs and form new ones. An essential aspect of this development is being exposed to diverse perspectives. This is especially so for many students, given that college is their first experience of living and working with people whose backgrounds are different from their own. Students are bound to meet, likely for the first time, individuals from remote areas of the country or world, who are of different racial/ethnic backgrounds, of different religious beliefs, and of different political ideologies. This exposure to diverse backgrounds and opinions can provide an opportunity for students to question their previously held beliefs and develop their own principled reasoning, as described in Kohlberg's theory of moral development. In fact, researchers argue that this intercultural maturity is a developmental process for young adults (King & Baxter

Magolda, 2005). In the four years of undergraduate study, students can develop a greater understanding of their own ethical principles, as demonstrated here by the senior students' higher N2 scores.

These results show that, contrary to prior arguments (Cech, 2014), students reach higher levels of ethical development during their time in engineering programs. This development is critical for engineering students as their work can have profound impacts on communities. Through critical thinking and a postconventional level of morality, students are more likely to demonstrate an understanding of the societal impacts of their work. This understanding can motivate engineers to develop and design their work in ways that are harmful for none and beneficial to many. This could lead to students evaluating greater challenges, like issues of social equity, which are not easily resolved. Indeed, these challenges require deep thought and principled reasoning, a critical component of postconventional morality.

Interaction effects of University and Class Year

The ANOVA tests resulted in an interaction effect between university and class year for the Maintaining Norms (MN) scores, showing that MN scores are significantly different between seniors at the two universities ($p = 0.003$). Senior engineering students at University A (located in the Southern United States) scored lower than students at University B (located in the Midwestern United States). The MN score represents the conventional morality level in Kohlberg's theory of moral development, where individuals are most concerned with maintaining the social order and being seen as good by others (Thoma, 2006; van den Enden et al., 2019). With higher MN scores, students at University B are more likely to value honesty and a commitment to rules and norms. Engineering students with a high MN score may be exceptional students as they are likely concerned with following set rules and processes. This dedication to standard procedures is

important in engineering to ensure both quality and safety. Adherence to standard procedures leads to consistent quality, which is essential in any manufacturing or building process. Moreover, those who scored high in MN would likely understand the value and importance of following strict safety codes. These safety codes ensure that both workers and consumers are protected. This adherence to safety procedures may demonstrate a dedication to others' wellbeing, which is a distinction from the preconventional morality level.

However, there are disadvantages for engineers with high MN scores and low N2 scores, including a lack of commitment to innovation and change. When an engineer is dedicated to traditional practices, they are less likely to independently explore new opportunities for improvement. For instance, the engineering industry traditionally lacks gender, racial, and ethnic diversity. Those engineers who do not value innovation and instead insist on maintaining norms might disregard the value of diversifying the workforce. The consequent lack of inclusion can be detrimental not only internally for the engineering industry, but also for society in the work that is produced. For instance, facial recognition software has received attention for its tendency to identify white faces with much greater accuracy than the faces of people of color (Buolamwini & Gebu, 2018; Lohr, 2018). The inclusion of people of color on research teams could help mitigate some of the design shortcomings. When engineers are committed to questioning norms, they can better address imbalances in gender, racial, and ethnic representation. These changes are unlikely to happen if engineers' ethical development lingers in the Maintaining Norms stage.

Practical implications

The analysis here shows that university and class year have significant impacts on engineering students' ethical development. Through engineering coursework, students can combine critical thinking with ethical understanding to become more effective engineers.

Instructors can include ethical considerations in more of their lessons to encourage students' ethical development. Additionally, exposure to diverse perspectives throughout an undergraduate education can encourage greater ethical development (Parker et al., 2016). Universities could encourage this through initiatives to recruit a more diverse student population and to encourage interactions amongst students in student organizations and activities. Instructors can design courses that encourage students to learn about one another's backgrounds and to share stories of their lived experiences.

CONCLUSION

In this study, we have surveyed undergraduate engineering students at two universities to assess their ethical development. Using the Defining Issues Test (DIT-2), we obtained quantitative scores representing each students' level of ethical development. Using analysis of variance, we evaluated the association between DIT scores and students' university and class years. The results of these tests revealed that students' PI scores decrease between their first year and senior year, while their N2 scores increased over this time. Additionally, senior engineers at University B had higher MN scores than seniors at University A. It is beyond the scope of this study to reach definitive conclusions on why such associations were found. Nonetheless, we were able to discuss probable factors for, and outcomes of, the differences in ethical development between groups. Students at each university likely scored differently on the DIT-2 because ethics is taught differently in every program. While ABET does require ethics education, it does not specify details on how this should be accomplished. Universities can potentially improve the ethical development of their students by looking to other programs and implementing different teaching methods, including project-based learning, current events as case studies, and inclusive learning environments. Notably, exposing students to diverse perspectives and inclusive settings may

encourage greater ethical development. While students at the conventional level of moral development (with high Maintaining Norms scores) are likely to become competent engineers with a focus on design standards and quality control, engineers who reach the postconventional level (with high N2 scores) are more likely to embrace innovative and diverse ideas and thereby contribute to the future of the profession.

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(redacted for anonymity in review process)

STATEMENTS AND DECARATIONS

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Supplemental Information

Table S1. Univariate Analysis of Variance (ANOVA) for Personal Interest (PI) Score

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	sig
University	1	679	678.7	2.923	0.088	.
Class Year	3	1749	583	2.511	0.058	.
Political Leaning	4	894	223.6	0.963	0.427	
Religiosity	4	150	37.4	0.161	0.958	
Gender Identity	1	4275	4274.6	18.410	2.16E-05	***
Race/Ethnicity	1	629	628.8	2.708	0.101	
University: Class Year	3	400	133.5	0.575	0.632	
Political Leaning: Gender Identity	4	2196	549.1	2.365	0.052	.
Political Leaning: Race/Ethnicity	3	692	230.8	0.994	0.395	
Gender Identity: Race/Ethnicity	1	1023	1023.3	4.407	0.036	*
Residuals	474	110056	232.2			

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table S2. Post-hoc comparison test to probe the main effect of class year on Personal Interest (PI) Score

group 1	group 2	p.adj	sig
Class Year 1	Class Year 2	0.998	
Class Year 1	Class Year 3	0.822	
Class Year 1	Class Year 4	0.0915	.
Class Year 2	Class Year 3	0.743	
Class Year 2	Class Year 4	0.0754	.
Class Year 3	Class Year 4	0.452	

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table S3. Univariate Analysis of Variance (ANOVA) for Maintaining Norms (MN) Score

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	sig
University	1	2525	2525.4	14.420	1.65E-04	***
Class Year	3	275	91.56	0.523	0.667	
Political Leaning	4	10358	2589.44	14.786	2.15E-11	***
Religiosity	4	1920	480.04	2.741	0.028	*
Gender Identity	1	447	447.09	2.553	1.11E-01	
Race/Ethnicity	1	114	113.92	0.651	0.420	
University: Class Year	3	1191	397.16	2.268	0.080	.
Political Leaning: Gender Identity	4	2268	567.11	3.238	0.012	*
Political Leaning: Race/Ethnicity	3	2233	744.38	4.251	0.006	**
Gender Identity: Race/Ethnicity	1	148	147.5	0.842	0.359	
Residuals	474	83010	175.13			

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table S4. Post-hoc comparison test to probe the interaction effects of class year and university on

Maintaining Norms (MN) Score

term	group 1	group 2	p.adj	sig
<i>Class Year 1</i>	<i>University A</i>	<i>University B</i>	0.123	
<i>Class Year 2</i>	<i>University A</i>	<i>University B</i>	0.0551	.
<i>Class Year 3</i>	<i>University A</i>	<i>University B</i>	0.847	
<i>Class Year 4</i>	<i>University A</i>	<i>University B</i>	0.00291	***

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table S5. Univariate Analysis of Variance (ANOVA) for N2 Score

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	sig
<i>University</i>	1	4298	4297.7	24.728	9.24E-07	***
<i>Class Year</i>	3	1394	464.8	2.675	0.047	*
<i>Political Leaning</i>	4	4140	1035.1	5.956	1.06E-04	***
<i>Religiosity</i>	4	1737	434.3	2.499	0.042	*
<i>Gender Identity</i>	1	2144	2143.8	12.335	4.87E-04	***
<i>Race/Ethnicity</i>	1	694	694.1	3.994	0.046	*
<i>University: Class Year</i>	3	237	78.8	0.454	0.715	
<i>Political Leaning: Gender Identity</i>	4	1283	320.7	1.845	0.119	
<i>Political Leaning: Race/Ethnicity</i>	3	490	163.3	0.940	0.421	
<i>Gender Identity: Race/Ethnicity</i>	1	740	740.3	4.260	0.040	*
<i>Residuals</i>	474	82379	173.8			

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Table S6. Post-hoc comparison test to probe the main effect of class year on N2 Score

group 1	group 2	p.adj	sig
<i>Class Year 1</i>	<i>Class Year 2</i>	0.965	
<i>Class Year 1</i>	<i>Class Year 3</i>	0.81	
<i>Class Year 1</i>	<i>Class Year 4</i>	0.0347	*
<i>Class Year 2</i>	<i>Class Year 3</i>	0.98	
<i>Class Year 2</i>	<i>Class Year 4</i>	0.137	
<i>Class Year 3</i>	<i>Class Year 4</i>	0.262	

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

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Table S7. Summary statistics of control variables for DIT-2 Scores

	Personal Interest		Maintaining Norms		N2 Score	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
<i>Political Leaning</i>						
<i>Very Conservative</i>	24.00	14.04	44.89	14.95	25.23	10.90
<i>Conservative</i>	30.00	16.08	31.19	13.87	31.70	13.62
<i>Moderate</i>	30.29	16.64	27.91	13.61	34.14	14.43
<i>Liberal</i>	28.44	16.00	24.58	13.48	37.23	13.36
<i>Very Liberal</i>	26.48	12.72	19.30	13.41	41.57	13.02
<i>Religiosity</i>						
<i>A lot more religious</i>	28.21	16.58	32.41	16.01	34.25	13.22
<i>More religious</i>	29.49	16.91	31.30	14.53	30.70	13.66
<i>As religious</i>	28.83	15.25	25.40	13.36	36.27	14.05
<i>Less religious</i>	28.98	14.71	24.27	13.72	37.81	14.04
<i>A lot less religious</i>	28.64	15.67	23.22	13.72	37.62	14.19
<i>Gender</i>						
<i>Woman</i>	24.51	15.03	26.42	14.34	39.71	14.11
<i>Man</i>	31.27	15.54	26.70	14.56	33.31	13.63
<i>Race/Ethnicity</i>						
<i>Non-minority</i>	28.69	15.10	27.33	14.68	35.03	14.10
<i>Minority race</i>	29.37	17.04	24.86	13.85	36.83	14.14

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