Factors Related to Faculty Views Toward Undergraduate Engineering Ethics Education

Mr. Andrew Katz, Virginia Polytechnic Institute and State University

Andrew Katz is a graduate student in the Department of Engineering Education at Virginia Tech. He holds a B.S. in chemical engineering from Tulane University and M.Eng. in environmental engineering from Texas A&M University. Prior to beginning his studies at Virginia Tech he taught physics at a high school in Dallas, TX.

Dr. David B. Knight, Virginia Polytechnic Institute and State University

David Knight is an Assistant Professor and Director of International Engagement in the Department of Engineering Education and affiliate faculty with the Higher Education Program, Center for Human-Computer Interaction, and Human-Centered Design Program. His research tend to be at the macro-scale, focused on a systems-level perspective of how engineering education can become more effective, efficient, and inclusive.

Factors Related to Faculty Views Toward Undergraduate Engineering Ethics Education

Abstract

This study focuses on faculty members' views of how engineering ethics should fit within their own most frequently taught course and in the undergraduate engineering curriculum more generally. It draws on quantitative data from a survey administered to engineering faculty at a nationally representative sample of 31 institutions (n = 1,389 usable faculty responses). This analysis seeks to uncover variables that help explain the following: 1) how much faculty emphasize ethical issues in engineering practice in their most frequently taught undergraduate engineering course, 2) how much they emphasize the effect of beliefs and values on ethical decisions, and 3) the extent to which they believe the engineering curriculum should address ethical issues in multiple courses. Predictor variables included faculty departmental affiliation, rank, gender, years teaching at the college level, years working outside of academia, weekly number of hours spent on research, and type of course primarily taught (i.e., first-year design course, required engineering course, capstone design course). Results showed differences between faculty in certain engineering disciplines; civil engineering faculty members emphasized ethical issues in their courses to the greatest extent; electrical engineering and mechanical engineering faculty members were on the opposite end of the spectrum. Additionally, an emphasis on ethical issues was placed more heavily by faculty members teaching first-year engineering design courses and capstone design courses than those teaching more traditionally technical courses (i.e. required engineering courses, fundamental math and science courses, and engineering electives). One might explain this with a sandwich theory of program course design in which the first-year and final-year design courses contain the "non-technical" material, and the intervening second and third years are reserved for technical content stripped of contextual discussions on topics like ethics.

Introduction

Ethical engineering practices form a linchpin of modern society. Ask anyone who bought a Volkswagen diesel with the emissions test cheat controls whether they would unquestioningly buy from that company again, and then extrapolate that across all economic standards if engineers in every industry decided to forego ethical behavior – an entire area of economic research considers this question of the importance of trust in social welfare[1]. Then consider the public health and social justice implications such as the estimated 4,000 unnecessary deaths due to the excess NOx emitted into the atmosphere[2]. Most engineers will recognize the double-edged potential for their profession to either promote or debase communal welfare. It is irrefutably in society's long-term interest that engineers act ethically; infusing formal ethics education (admittedly in conjunction with numerous other factors) into the curriculum is important for developing engineers.

One simply needs to read headlines in the news to see the impact of unethical behavior by engineers – illicit emissions controls, negligent pipeline maintenance, and improper municipal water treatment are some of the more conspicuous recent examples. Despite such enormous potential for negative impacts, helping developing engineers consider ethical aspects of their eventual professional work receives inconsistent treatment in undergraduate programs. Because faculty members develop and deliver curricula, studying their perspectives is an important way to understand how the undergraduate education system might emphasize ethics to a greater (or lesser) degree. The current study helps to address this issue by drawing on a large national survey administered to engineering faculty. The survey solicited their perspectives on issues related to a host of areas across engineering curricula, including engineering ethics.

Identifying some of these factors that relate to faculty views toward engineering ethics in the curriculum will offer information to several interested parties. First, it can inform future engineering ethics education research by identifying factors to consider when studying variations in teaching practices. Second, it will interest reformers and policymakers by identifying characteristics exhibited by faculty members who may be more amenable or averse to incorporating engineering ethics in their courses (i.e., potential "change agents"). Finally, this research will add to the body of scholarly work on factors affecting the interaction between faculty characteristics and their curricular perspectives, which is of interest to a broad range of higher education researchers and practitioners.

Review of the Literature

There are multiple places to conduct investigations about the dynamics of engineering ethics in society. One place to conduct such studies is the higher education system, where students learn engineering concepts and earn their bachelor's degrees. Since the bachelor's degree in engineering is the requirement for licensure in most states – and since engineering ethics is a paramount topic in professional practice – engineering ethics education should suffuse the undergraduate curriculum to help form contributing members of society and communicate the importance and relevance of ethics in professional practice, a point argued elsewhere[3].

Asserting that engineering ethics should be taught in undergraduate engineering courses assumes that curricular content makes a difference in shaping the beliefs and expectations students hold as they transition into their professional careers. Such an assumption is warranted given the way other topics appear in the curriculum. For example, if an emphasis on teamwork and problem-solving were not perceived as relevant to professional practice, then one would not expect them to receive as much attention as they do[4,5]. Similarly, engineering ethics is another such pivotal topic, and therefore one would expect it to appear in undergraduate courses. Yet, this is not uniformly the case. To understand the discrepancy in engineering ethics coverage, this work focuses on some of the central actors in course content decisions – engineering department faculty members. To date, abundant research exists on the mechanics of teaching ethics, but there remains a paucity of work investigating what informs faculty decisions to teach ethics (or, conversely, not to teach it) and how they discern the manifold inputs affecting those decisions.

Over the past decade, research on engineering ethics in undergraduate programs has considered myriad perspectives. One branch of work has approached it from the student perspective, ranging from an investigation on student perspectives toward ethics and professional identity[6] to a more tangential approach looking at students' views toward social responsibility[7,8]. A separate branch has also looked at this topic from recent graduates' perspectives and encounters with ethical dilemmas as practicing engineers[9,10]. There has been less work, however, from the faculty perspective—and because faculty members develop and deliver curricula, studying their perspectives is an important way to understand how the undergraduate education system might emphasize ethics to a greater degree. Such work that does exist tends to analyze how faculty and departments teach engineering ethics in specific contexts[11], different programs that facilitate engineering ethics education[12], specific issues limited to academic integrity[13], and what lies within the bounds of engineering ethics[14]. However, the faculty writ large has received comparatively less attention. The literature that does exist on engineering faculty views on engineering ethics has tended to be limited in scope and specific to certain engineering disciplines.

In general, among faculty of different ranks, and between gender, faculty members allocate their time differently between teaching, research, and service[15]. Personal faculty judgments are further affected by institutional constraints as well as personal affective orientations, beliefs, and experiences[16]. Thus, given the role of personal factors in curricular decision-making[17], and the limitations of using an existing dataset, this paper considered the following factors as explanatory variables: faculty departmental affiliation, gender, rank, and primary course taught. Continuous explanatory variables included: years teaching at college level, years spent in industry before teaching, years spent in industry while teaching, and number of hours involved in research-related activities on a weekly basis. The study rested on a conception of faculty agency that imbues them with a capacity for substantive decision-making[18] and thus inquired into their perspectives on engineering ethics education to locate important areas of consideration for those interested in improving engineering ethics in both the classroom and the professional world. It further tested the hypothesis that certain personal characteristics such as disciplinary concentration, work experience, and teaching experience influence those perspectives. The conceptual framework is loosely informed by Lattuca and Stark's Academic Plan Model, shown in Figure 1. The diagram illustrates the confluence of factors that can affect an academic plan's design, which includes faculty members – the unit of analysis for the present work.

Figure 1. Academic Plan Model from Lattuca and Stark[17].*

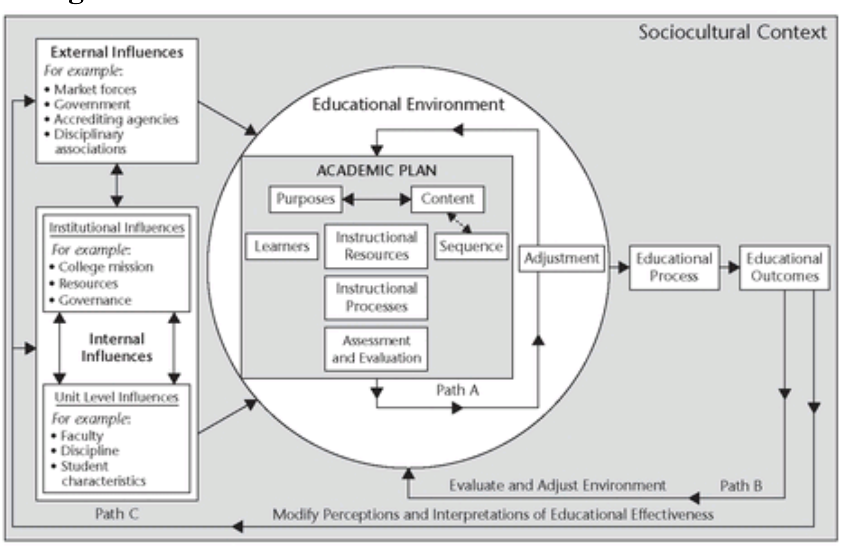


*Figure used with author's permission via personal correspondence.

Starting with the observation that some faculty teach engineering ethics in their courses while others do not[19], one question arises: what is the difference between groups of faculty members in how they conceptualize engineering ethics education? If we could better characterize the conceptual frameworks around the perceptions, beliefs, and attitudes that engineering faculty harbor toward ethics education, then we could infuse faculty development programs and future research with these lessons. Identifying gaps between the prevalent mental models in discrete faculty groups will reveal said values, beliefs, attitudes, and motivation that can be leveraged in faculty development interventions, with the ultimate goal being increased and improved undergraduate engineering ethics education.

Research Questions

By assuming that faculty members pursue curricular decisions in part based on their own beliefs and worldviews[17] and recognizing that engineering faculty incorporate engineering ethics in their courses to varying degrees[11], this analysis was catalyzed by the overarching question: why does engineering ethics appear in engineering education to varying degrees? **In particular, how much do certain faculty member factors relate to engineering faculty members' views of engineering ethics?**

Methods

Our secondary data analysis draws on a nationally representative survey data set that includes 31 four year institutions (see Table 1). Developed as a part of an NSF study, the dataset includes survey responses from engineering students, faculty, administrators, and alumni; the survey focused on the organizational conditions, policies and practices, and student experiences supporting the development of a variety of student learning outcomes. The institutional sample was drawn using the following strata: six engineering disciplines (biomedical/bioengineering, chemical, civil, electrical, industrial, and mechanical), three levels of highest degree offered (bachelor's, master's, and doctorate), and two levels of institutional control (public and private). This sample design resulted in a distribution of institutions that were representative of the engineering education population with respect to type, mission, and highest degree offered. Five institutions were purposefully included because they were case study sites in a companion qualitative study. Because one of these institutions only offered general engineering, three institutions that offered general engineering degrees were included for comparison purposes. The remaining institutions were chosen randomly.

Table 1. Institutional sample.

Research Institutions:	Master's/Special Institutions:
Arizona State University (Main & Polytechnic)[a]	California Polytechnic State University[c]
Brigham Young University	California State University, Long Beach[c]
Case Western Reserve University	Manhattan College
Colorado School of Mines	Mercer University
Dartmouth College	Rose-Hulman Institute of Technology
Johns Hopkins University	University of South Alabama
Massachusetts Institute of Technology[a]	
Morgan State University[b]	
New Jersey Institute of Technology	**Baccalaureate Institutions:**
North Carolina A&T[b]	Harvey Mudd College[a]
Purdue University	Lafayette College
Stony Brook University	Milwaukee School of Engineering
University of Illinois at Urbana-Champaign	Ohio Northern University
University of Michigan[a]	Penn State Erie, The Behrend College
University of New Mexico[c]	West Virginia University Institute of Technology
University of Texas, El Paso[c]	
University of Toledo	
Virginia Polytechnic Institute and State University[a]	

[a] Institution participating in the companion qualitative study
[b] Historically Black College or University
[c] Hispanic-Serving Institution

A university survey research center collected data in 2008 through a web-based questionnaire. There were n = 1,389 total responses to the survey, of which n = 1,217 were tenure-track professors. For the statistical tests that included rank as an explanatory factor, only tenure-track professors were included; otherwise tests included the entire survey sample. Survey respondents also had the option to indicate "other" for their discipline; these cases were excluded from the statistical tests that included department affiliation as an explanatory factor. Table 2 displays the sample demographics.

Table 2. Faculty member demographics.

Factor	Factor Levels	Frequency	Percent
Department	Bio-medical or Bio-engineering	69	4.9%
	Chemical Engineering	133	9.6%
	Civil Engineering	245	17.6%
	Electrical Engineering	477	34.4%
	General Engineering/ Engineering Science	74	5.3%
	Industrial Engineering	87	6.3%
	Mechanical Engineering	305	21.9%
Gender	Female	172	12.4%
	Male	1,217	87.6%
Faculty Member Rank	Assistant professor	279	22.9%
	Associate professor	361	29.6%
	Full professor	578	47.5%

The study focuses specifically on faculty views of engineering ethics in their own most frequently taught course and in the engineering curriculum more generally. The analysis sought to uncover variables that help explain the following: 1) how much faculty emphasize ethical issues in engineering practice in their most frequently taught undergraduate engineering course, 2) how much they emphasize the effect of beliefs and values on ethical decisions, and 3) the extent to which they believe the engineering curriculum should address ethical issues in multiple courses. Independent variables include faculty departmental affiliation, rank, gender, years teaching at the college level, years working outside of academia, weekly number of hours spent on research, and type of course primarily taught (e.g. first-year design course, required engineering course, capstone design course).

This specific paper utilized weighted responses from 1,389 faculty members on items related to their emphasis on ethics and their beliefs on whether the undergraduate engineering curriculum should emphasize ethics. Our research focused on faculty responses to three survey items:

1. How much do you emphasize the importance of ethical beliefs in engineering?
2. How much do you emphasize examining beliefs and values and how they affect ethical decisions?
3. To what extent do you agree that the engineering curriculum should cover ethical issues in multiple courses?

Each of the survey items was rated on a five-point Likert-style scale ranging from little/no emphasis for survey items 1 and 2 (or strongly disagree for survey item 3) to very strong emphasis for survey items 1 and 2 (or strongly agree for survey item 3).

A multifactorial ANOVA was performed for each of the three survey items listed above with faculty member gender (levels: male, female), rank (levels: assistant professor, associate professor, full professor), and departmental affiliation (levels: biomedical engineering, chemical engineering, civil engineering, electrical engineering, general engineering/engineering science, industrial engineering, and mechanical engineering) as the explanatory factors. Post-hoc comparisons were performed for rank and department affiliation using the Games-Howell test because of non-homogeneous variances between groups. A one-way ANOVA was performed for each of the three survey items listed above with "type of course taught" as the explanatory factory (levels: first-year design course, fundamental math or science course, required engineering course, engineering elective, and capstone design). Post-hoc comparisons were performed for rank and department affiliation using the Games-Howell test. For the continuous predictor variables, Pearson's product-moment correlation coefficients were calculated between each of the survey item responses and the four quantitative predictor variables – number of years spent teaching at the college level, number of years spent working in industry prior to academia, number of years spent working in industry while in academia, and weekly hours spent on research-related activities.

The null hypotheses associated with these tests were as follows, where X = {1, 2, 3} and Y = {years teaching for multiple years; years spent in industry before entering academia; years spent in industry while in academia; hours spent conducting research on a weekly basis}:

- H_o: there is no statistically significant difference in responses to survey item X between faculty from different engineering departments.

- H_o: there is no statistically significant difference in responses to survey item X between male and female faculty members
- H_o: there is no statistically significant difference in responses to survey item X between assistant, associate, and full professors.
- H_o: there is no statistically significant difference in responses to survey item X between faculty teaching different kinds of engineering courses.
- H_o: there is no statistically significant correlation between responses to survey item X and work experience Y.

Results

Categorical Factors

Emphasis on ethical issues in engineering practice. Results related to the multifactorial ANOVA for survey item "How much do you emphasize the importance of ethical beliefs in engineering?" are shown in Table 3. Factors included in the test were department affiliation, rank, and gender. There were no statistically significant main effects for rank, gender, or department affiliation. There were statistically significant interaction effects, however, between department and gender ($p = 0.012$, $\eta_p^2 = 0.015$), department and rank ($p = 0.003$, $\eta_p^2 = 0.027$), and all three factors ($p < 0.001$, $\eta_p^2 = 0.033$). Interaction effects between department and gender are shown in Figure 2. Interaction effects between department and rank are shown in Figure 3. These results suggest a differential effect on faculty emphasis of ethical issues in engineering practice (in their class) based on their departmental affiliation, gender, and rank. While potentially the partial effect of comparatively small sample sizes for some of the individual groups (e.g., female assistant professors in biomedical engineering), this trend may warrant further investigation. For example, are professors in certain departments, at certain steps in the tenure process, more likely than other professors to emphasize ethical issues in engineering practice? If so, are there individual or systemic characteristics that make this more likely – especially ones that other institutions can replicate? The reader should note this general trend or interaction effects between rank, gender, and/or department affiliation, also applied in analyses for survey items 2 and 3, as discussed next.

Figure 2. Means plot for interaction effects between gender & department affiliation for item 1.

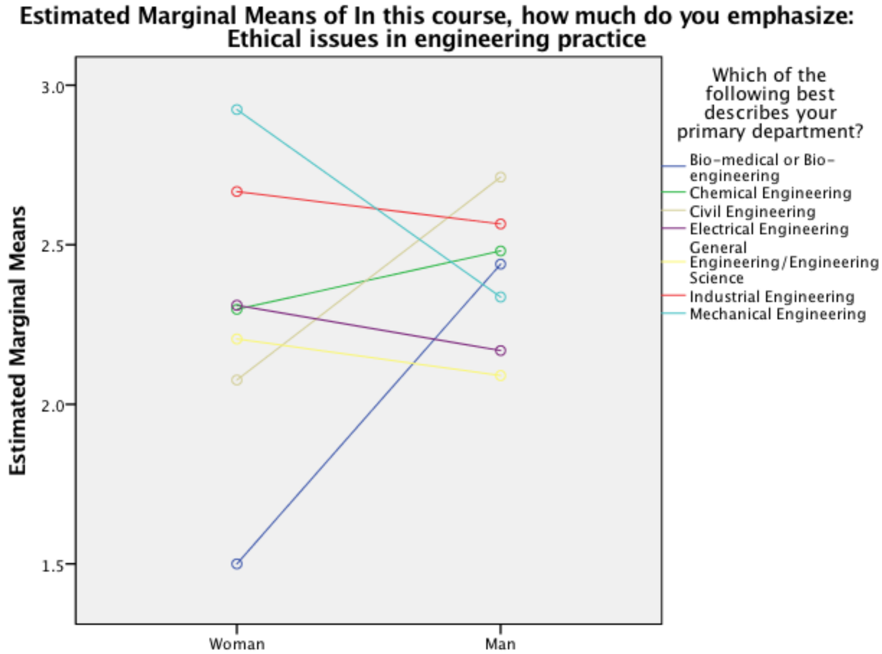
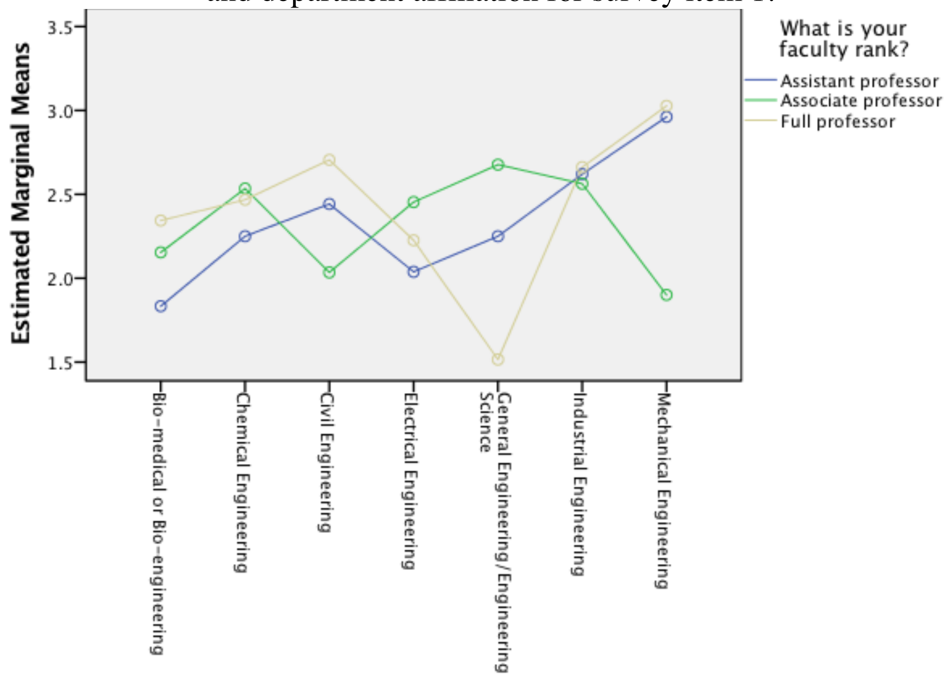


Table 3. Multifactorial ANOVA for survey item 1.

Item 1: In this course, how much do you emphasize: Ethical issues in engineering practice?						
Source	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power[b]
Corrected Model[a]	38	3.355	2.832*	.000	.091	1.000
Intercept	1	1315.849	1110.850*	.000	.510	1.000
Department	6	2.235	1.887	.080	.010	.705
Gender	1	.479	.404	.525	.000	.097
Rank	2	.016	.014	.987	.000	.052
Dept * Gender	6	3.241	2.736*	.012	.015	.877
Dept * Rank	12	2.936	2.479*	.003	.027	.974
Gender * Rank	2	.033	.028	.972	.000	.054
Dept*Gend*Rank	9	4.786	4.041*	.000	.033	.997
Error	1069	1.185				
Total	1108					
Corrected Total	1107					
a. R^2 = .091 (Adjusted R Squared = .059); * indicates significant at the $p < 0.05$ level						
b. Computed using alpha = .05						

Figure 3. Means plot for interaction effects between rank and department affiliation for survey item 1.



Emphasis on examining beliefs and values and how they affect ethical decisions. Results related to the multifactorial ANOVA for the item, "How much do you emphasize examining beliefs and values and how they affect ethical decisions?" are shown in Table 4. Factors included in the test were department affiliation, rank, and gender. There were statistically significant main effects observed from department affiliation ($p = 0.013$, $\eta_p^2 = 0.016$) and gender ($p = 0.039$, $d = 0.19$) but no statistically significant main effect from rank ($p = 0.064$). Post hoc comparisons using Games-Howell are shown in Table 6; there were statistically significant differences between civil and electrical engineering ($p < 0.001$, $d = 0.42$), civil and chemical ($p < 0.001$, $d = 0.54$), and industrial and chemical ($p = 0.025$, $d = 0.51$). (Note: The department with higher faculty means on the survey item are listed first in the preceding listing.) There were also statistically significant interaction effects between department and gender ($p < 0.001$, $\eta_p^2 = 0.027$), department and rank ($p = 0.03$, $\eta_p^2 = 0.022$), and all three factors ($p < 0.001$, $\eta_p^2 = 0.038$). Interaction effects between department and gender are shown in Figure 4. Interaction effects between department and rank are shown in Figure 5.

Table 4. Multifactorial ANOVA for survey item 2.

Source	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power[b]
Corrected Model[a]	38	5.095	4.292*	.000	.136	1.000
Intercept	1	961.453	809.911*	.000	.439	1.000
Department	6	3.229	2.720*	.013	.016	.874
Gender	1	5.078	4.277*	.039	.004	.542
Rank	2	3.269	2.754	.064	.005	.544
Dept * Gender	6	5.767	4.858*	.000	.027	.992
Dept * Rank	12	2.261	1.905*	.030	.022	.912
Gender * Rank	2	1.324	1.115	.328	.002	.247
Dept * Gender * Rank	9	5.451	4.592*	.000	.038	.999
Error	1035	1.187				
Total	1074					
Corrected Total	1073					

a. R^2 = .136 (Adjusted R Squared = .104); * indicates significant at the $p < 0.05$ level

b. Computed using alpha = .05

Figure 4. Means plot for interaction effects between gender and department affiliation for survey item 2.

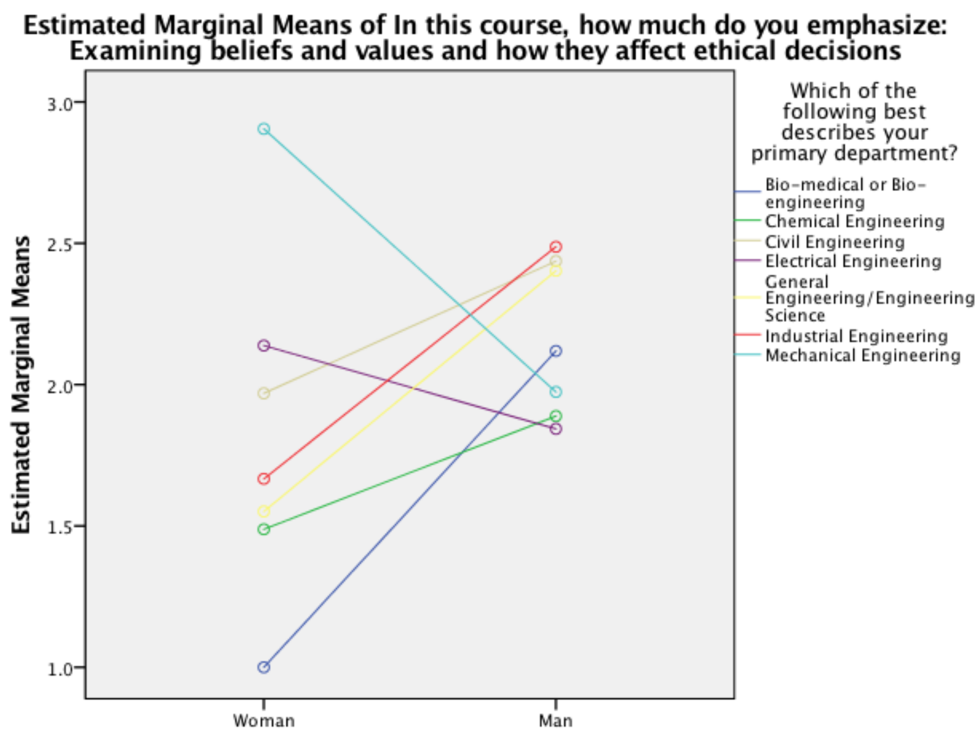


Figure 5. Means plot for interaction effects between rank and department affiliation for survey item 2.

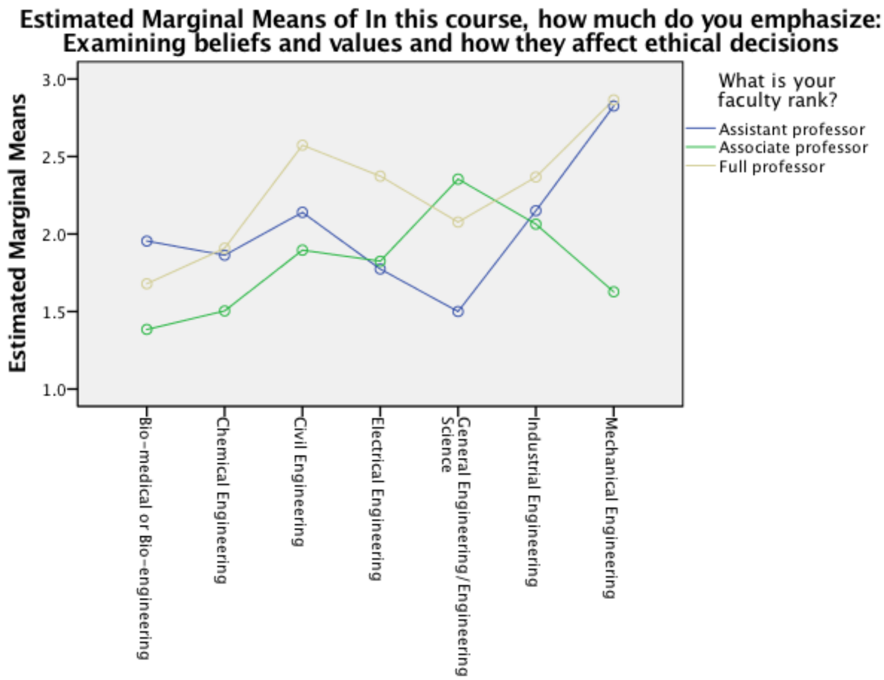


Table 5. Post hoc comparisons for departmental affiliation and survey items 2 and 3.

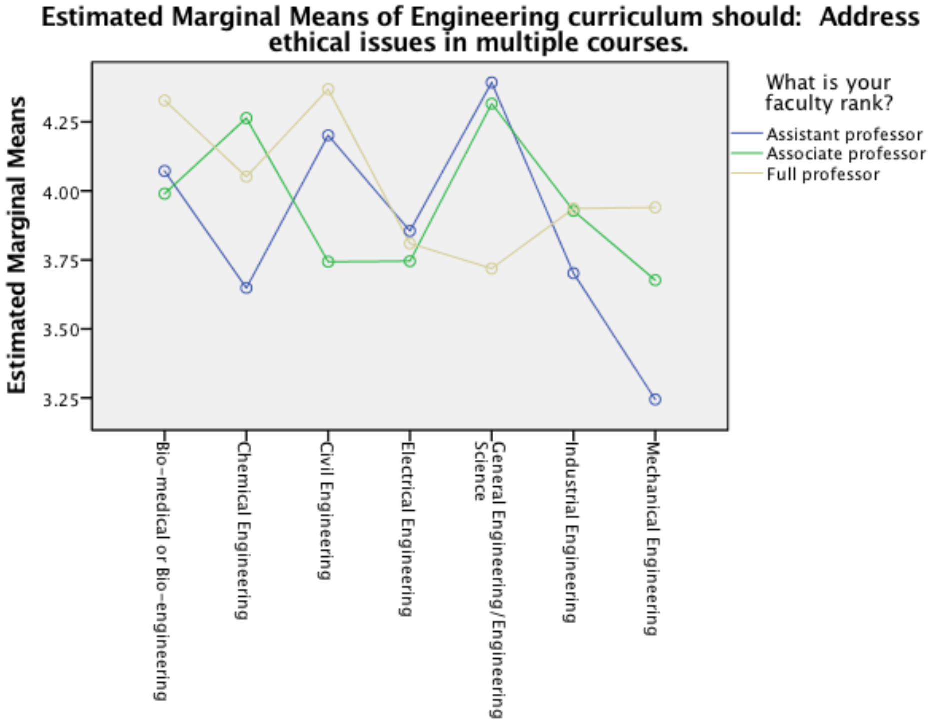
Post-Hoc Comparisons for Department Affiliation Main Effect Using Games-Howell					
Dependent Variable	(I) Which of the following best describes your primary department?	(J) Which of the following best describes your primary department?	Mean Difference (I-J)	Std. Error	Sig.
In this course, how much do you emphasize: Examining beliefs and values and how they affect ethical decisions	Civil Engineering	Electrical Engineering	.486*	.099	.000
	Chemical Engineering	Civil Engineering	-.628*	.140	.000
		Industrial Engineering	-.588*	.182	.025
Engineering curriculum should: Address ethical issues in multiple courses.	Civil Engineering	Mechanical Engineering	.353*	.062	.000
	Electrical Engineering	Chemical Engineering	-.231	.079	.056
		Civil Engineering	-.396*	.063	.000
		General Engineering/Engineering Science	-.520*	.112	.000
		Industrial Engineering	-.289*	.092	.034
	General Engineering/Engineering Science	Mechanical Engineering	.477*	.112	.001
*. The mean difference is significant at the $p < 0.05$ level.					

Belief that the engineering curriculum should cover ethical issues in multiple courses. Results related to the multifactorial ANOVA for the survey item “To what extent do you agree that the engineering curriculum should cover ethical issues in multiple courses?” are shown in Table 5. Factors included in the test were department affiliation, rank, and gender. There were statistically significant main effects observed from department affiliation ($p < 0.001$, $\eta_p^2 = 0.022$) and gender ($p = 0.009$, $\eta_p^2 = 0.006$). Post hoc comparisons for department affiliation using Games-Howell are shown in Table 6. There were statistically significant differences between several engineering disciplines: electrical engineering faculty scored lower than chemical ($p = 0.056$, $d = 0.29$), civil ($p < 0.001$, $d = 0.49$), general ($p < 0.001$, $d = 0.65$), and industrial ($p = 0.034$, $d = 0.36$). Mechanical engineering faculty had a lower mean score on item 3 than general ($p = 0.001$, $d = 0.59$) and civil ($p < 0.001$, $d = 0.44$). There were also statistically significant interaction effects between department and rank ($p < 0.001$, $\eta_p^2 = 0.031$) and all three factors ($p = 0.00$, $\eta_p^2 = 0.026$). Interaction effects between department and rank are shown in Figure 6. As before, these tended to suggest that there were significant interactions between the combination of faculty member department affiliation, rank, and gender.

Table 6. Multifactorial ANOVA for survey item 3.

Item 3: Engineering curriculum should: Address ethical issues in multiple courses.						
Source	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power[b]
Corrected Model[a]	40	2.563	4.333*	.000	.129	1.000
Intercept	1	4082.413	6903.118*	.000	.855	1.000
Dept	6	2.573	4.350*	.000	.022	.984
Gender	1	4.069	6.881*	.009	.006	.746
Rank	2	.827	1.399	.247	.002	.301
Dept * Gender	6	1.087	1.837	.089	.009	.692
Dept * Rank	12	1.853	3.133*	.000	.031	.995
Gender * Rank	2	1.035	1.751	.174	.003	.368
Dept * Gender * Rank	11	1.678	2.837*	.001	.026	.984
Error	1169	.591				
Total	1210					
Corrected Total	1209					
a. $R^2 = .129$ (Adjusted R Squared = .099); * indicates significant at the $p < 0.05$ level						
b. Computed using alpha = .05						

Figure 6. Means plot for interaction effects between rank and department affiliation for survey item 3.



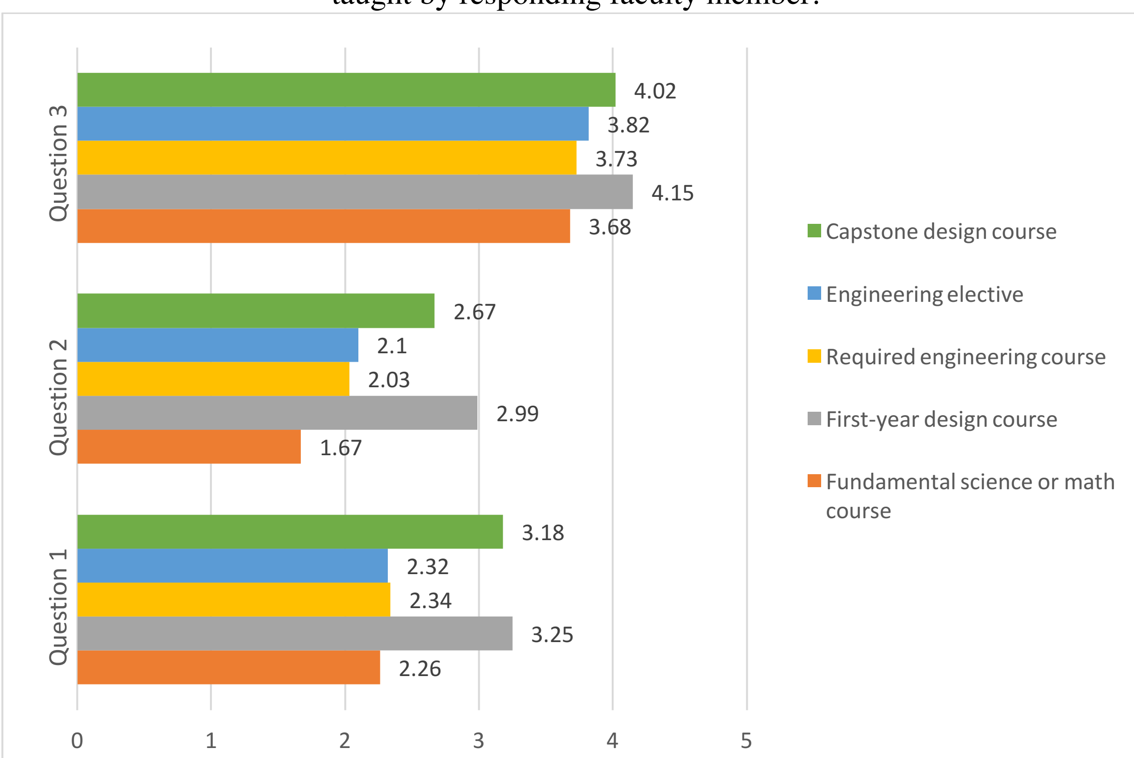
Effects of type of course taught most often. A one-way ANOVA was performed using each of the three survey items as the outcome variable and the primary course a faculty teaches as the explanatory factor (levels: first-year design course, fundamental science or math course, required engineering course, engineering elective, and capstone design). Due to failure of Levene's homogeneity of variance test, and unequal group sizes, the post-hoc comparisons used the Games-Howell test. Results from the one-way ANOVA are shown in Table 7. In general, there were statistically significant differences between first-year design course or capstone course responses and technical courses (science/math, required engineering, and engineering elective), with the faculty members who teach the former category of course indicating higher levels of emphasis than faculty teaching the latter category. Statistically significant results from the post hoc comparisons using Games-Howell are shown in Table 8. The test compared differences for each of the three survey items between faculty who taught one of the five types of course. Figure 7 shows the mean scores for faculty teaching each of these courses for each survey response item.

Table 7. One-way ANOVA comparisons for primary course taught by faculty on survey items 1, 2, and 3.

		Sum of Squares	df	Mean Square	F	Sig.
In this course, how much do you emphasize: Ethical issues in engineering practice	Between Groups	109.305	4	27.326	21.806*	.000
	Within Groups	1561.434	1246	1.253		
	Total	1670.740	1250			
In this course, how much do you emphasize: Examining beliefs and values and how they affect ethical decisions	Between Groups	79.908	4	19.977	15.461*	.000
	Within Groups	1558.310	1206	1.292		
	Total	1638.218	1210			
Engineering curriculum should: Address ethical issues in multiple courses.	Between Groups	18.277	4	4.569	7.143*	.000
	Within Groups	825.820	1291	.640		
	Total	844.097	1295			

* indicates significant at $p < 0.05$ level

Figure 7. Faculty member reports (means) of engineering ethics topics sorted by primary course taught by responding faculty member.



Question 1: In this course, how much do you emphasize ethical issues in engineering practice
Question 2: In this course, how much do you emphasize examining beliefs and values and how they affect ethical decisions?

Question 3: Engineering curriculum should address ethical issues in multiple courses.

Table 8. Statistically significant post hoc comparisons for primary course taught by faculty on survey items 1, 2, and 3.

Post-Hoc Comparisons Using Games-Howell					
Dependent Variable	(I) Which category best describes this course?	(J) Which category best describes this course?	Mean Difference (I-J)	Std. Error	Sig.
In this course, how much do you emphasize: Ethical issues in engineering practice	First-year design course	Fundamental science or math course	1.168*	.329	.006
		Required engineering course	1.113*	.240	.000
		Engineering elective	1.100*	.248	.001
	Capstone design course	Fundamental science or math course	.919*	.254	.006
		Required engineering course	.865*	.118	.000
		Engineering elective	.852*	.133	.000
In this course, how much do you emphasize: Examining beliefs and values and how they affect ethical decisions	First-year design course	Fundamental science or math course	1.445*	.268	.000
		Required engineering course	1.123*	.180	.000
		Engineering elective	1.034*	.191	.000
	Capstone design course	Fundamental science or math course	.975*	.238	.001
		Required engineering course	.654*	.131	.000
		Engineering elective	.565*	.145	.001
Engineering curriculum should: Address ethical issues in multiple courses.	First-year design course	Fundamental science or math course	.570*	.178	.017
		Required engineering course	.546*	.121	.001
		Engineering elective	.458*	.127	.006
	Capstone design course	Required engineering course	.302*	.073	.001
*. The mean difference is significant at the 0.05 level.					

Continuous Variables

A Pearson product-moment correlation coefficient was computed for the relationship between each of the three ethics-related survey items and four continuous predictor variables related to time spent teaching, time spent working in industry, and time spent researching. These results are shown in Table 9. For the first survey item (emphasis on ethical issues in engineering practice) there were statistically significant positive correlations with time spent in industry before academia ($r = 0.133$, $n = 1{,}252$, $p < 0.001$) and time spent in industry while in academia ($r = 0.197$, $n = 1{,}252$, $p < 0.001$). For the second survey item (emphasis on examining beliefs and values) there were statistically significant positive correlations with time spent in industry before academia ($r = 0.097$, $n = 1{,}211$, $p = 0.001$) and time spent in industry while in academia ($r = 0.192$, $n = 1{,}211$, $p < 0.001$). For the third survey item (belief that engineering curriculum should address ethical issues in multiple courses) there was a statistically significant negative correlation with number of hours weekly spent on research-related activities ($r = -0.076$, $p = 0.005$, $n = 1{,}389$). Statistically significant correlations are shown in bold in the table.

Table 9. Correlations table for continuous variable and each survey item.

		In this course, how much do you emphasize: Ethical issues in engineering practice?	In this course, how much do you emphasize: Examining beliefs and values and how they affect ethical decisions?	Engineering curriculum should: Address ethical issues in multiple courses.
Years teaching at the college level (excluding graduate teaching assistantships)	Pearson Correlation	-.007	.005	-.037
How many years have you worked as an engineer: While employed full-time as a faculty member	Pearson Correlation	**.197***	**.192***	.031
How many years have you worked as an engineer: Before working full-time as a faculty member	Pearson Correlation	**.133***	**.097***	-.028

Over the past three years, approximately how many hours per week did you spend of research-related activities?	Pearson Correlation	-.052	-.012	**-.076***[*]
* Statistically significant at $p < 0.01$				

A summary table of statistically significant results is shown in Table 10. The table indicates whether a statistically significant effect was observed for each predictor on each survey item.

Table 10. Summary table of statistical tests for each investigated survey item.[*]

		Outcome variables		
Type of variable	Factor/Predictor	Survey Item 1	Survey Item 2	Survey Item 3
Categorical	Gender	--	X	X
	Rank	--	--	--
	Department	--	X	X
	Dept * Rank	X	X	X
	Dept * Gender	X	X	--
	Rank * Gender	--	--	--
	Dept * Gender * Rank	X	X	X
	First-year course vs. technical courses	X	X	X
	Capstone Course vs. technical courses	X	X	--
Continuous	Years Teaching	--	--	--

	Industry Experience pre-Academia	(+)	(+)	--
	Years Industry Experience During Academia	(+)	(+)	--
	Weekly Research Hours	--	--	(-)

*The table indicates whether a statistically significant result was observed for each predictor variable on each survey item. Observed statistically significant results are marked with “X”. Observed statistically significant positive correlations are marked with “(+)” and negative correlations are marked with “(-)”.

Discussion

Effects of Faculty Characteristics

The means comparisons for the three survey item responses using one-way ANOVA and multifactorial ANOVA with post hoc comparisons for department affiliation yielded three notable results. First, faculty in certain departments emphasize the importance of ethics in their courses more than faculty members in other departments. Electrical and mechanical engineering faculty members tended to be on the lower end of the spectrum, emphasizing concepts related to ethics to a lesser degree, while civil and industrial engineering faculty members tended to occupy the other end. The latter result might be explained by the nature of those professions working more closely with designs that directly affect large populations, although each respective professional society has its own code of ethics, in addition to the National Society of Professional Engineers code. Likewise, electrical and chemical engineers may spend less time working on designs that directly interface with other people. It could also be the case that there is a discrepancy in the quantity and nature of ethical dilemmas each discipline faces to such a degree that there are differential needs for ethics education. Furthermore, it is possible that faculty members are attuned to these differences and tailor their course emphases accordingly. Though plausible, this theory disagrees with the evidence discussed below that shows a positive correlation between faculty members’ industry experience and emphasis on ethical issues in their courses.

Second, there were contradictory differences in responses to survey items two and three based on gender. Whereas male engineering faculty members place a higher emphasis than female engineering faculty members on examining beliefs and values and how they affect ethical decisions, the converse was true for believing that engineering curriculum should address ethical issues in multiple courses. One might have expected to see more consistency between the two, with female faculty having a higher mean score than male faculty on both survey items or vice versa. This might be explained by the nature of the survey items. Survey item two asked about current practices in their specific course, but survey item three asked about general curricular beliefs. A particular faculty member could feel constrained by the curricular content of their own course while also harboring general beliefs about the desirable curriculum structure. In this way, one could observe faculty members not emphasizing engineering ethics in their own course while still believing that engineering ethics should be covered in multiple courses; those two beliefs are not mutually exclusive. Additionally, and beyond the scope of our analyses, there could be systematic differences in the types of courses that male and female faculty are assigned to teach most regularly.

Third the interaction effects between department affiliation and both rank and gender may require further exploration in subsequent studies. This finding may have been a statistical anomaly from unequal group sizes or there could be some other moderating variables unaccounted for that could make full professors in certain disciplines emphasize engineering ethics differently than other full professors in other disciplines (and the same would apply for assistant and associate professors).

Effects of Course Type

Faculty teaching either first-year design courses or capstone courses exhibited higher means on all three survey items when compared with faculty who teach more traditionally "technical" courses (i.e., required engineering courses, elective engineering courses, and fundamental math or science courses). This evidence might point toward a "sandwich theory" of engineering programs in which students learn about non-technical content like engineering ethics in their first and last years and focus on technical content sandwiched in the middle years. If true, the sandwich theory could prove detrimental by communicating to students that there is a disjunction between the technical and non-technical to such a degree that someone can consider one without the other. In doing so, it is possible to miss the forest for the trees and lose sight of the fact that engineers are working to design things *for* people. This, in turn, requires attributes like ethical behavior. Treating engineering and ethics as separate topics might culminate in students prioritizing the former over the latter either for expediency or lack of appreciation for their work and the importance of ethical conduct. Paradoxically, such a practice could ultimately do more harm than good. On the positive side, the sandwich theory is better than the "one-and-done" theory in which engineering ethics might appear only once at the beginning of a student's undergraduate engineering program and never again. At least with this bookend approach students encounter the topic of engineering ethics multiple times, especially in design contexts that more closely mimic their potential future professional settings. We question, however, whether this "sandwich" approach to ethics education is the most optimal educational design for developing ethical engineers.

Effects of Industry Experience

Duration of industry experience positively correlated with higher scores on the two survey items that addressed what faculty members emphasize in their courses. This finding might suggest that industry experience leads to an appreciation for the importance of ethical decision making in engineering practice, which translates back into the classroom as professors prepare their students to work in industry after graduation. Furthermore, as a faculty member spends more time in industry, they may be exposed to more instances where ethical decision-making played an important role in their professional lives – or they witnessed more instances of ethical ambiguity – and this in turn influenced how they prepare future engineers. Such an explanation would assume that faculty members make current pedagogical choices based on previous experience, as suggested by the Shavelson and Stern model[16].

Future work studying faculty members who do or do not teach engineering ethics can build upon this quantitative survey research with qualitative interviews with faculty members to help unpack the present study's results. Among those questions could be an investigation into the discrepancies between civil and electrical engineering faculty members' responses. Additionally, the engineering education community could benefit from answering why the identified significant factors were particularly significant? That is to say, why does something like industry experience affect a faculty member's views of engineering ethics education?

Conclusion

Overall, this paper highlighted some potential factors affecting faculty member decisions regarding the extent to which they teach engineering ethics in their courses. Researchers, leaders, and policymakers interested in engineering ethics and engineering ethics education should note the importance of faculty member experience and characteristics when designing their own work. As one might expect, there are important differences between faculty members from different departments, work experiences, career trajectories, and even courses taught. The current results can help guide future decisions in a more tailored way than a one-size-fits all approach.

References

1. Fehr, E. (2009). On the Economics and Biology of Trust. *Journal of the European Economic Association*, *7*(2/3), 235–266.
2. Drum, K. (2015, September 24). Volkswagen's Emissions Conspiracy May Have Killed at Least 4,000 People Worldwide. *Mother Jones*. Retrieved from http://www.motherjones.com/kevin-drum/2015/09/spreadsheet-day-how-many-people-did-vw-kill.
3. Fleischmann, S. T. (2004). Essential ethics — embedding ethics into an engineering curriculum. *Science and Engineering Ethics*, *10*(2), 369–381.
4. ABET. (2016). *Criteria for Accrediting Engineering Programs*. http://www.abet.org/accreditation/accreditation-criteria/.
5. Hirsch, P., & McKenna, A. F. (2008). Using reflection to promote teamwork understanding in engineering design education. *International Journal of Engineering Education*, *24*(2), 377–385.
6. Loui, M. C. (2005). Educational technologies and the teaching of ethics in science and engineering. *Science and Engineering Ethics*, *11*(3), 435-446-449.
7. Canney, N. E., & Bielefeldt, A. R. (2015). Differences in engineering students' views of social responsibility between disciplines. *Journal of Professional Issues in Engineering Education and Practice*, *141*(4), 4015004
8. Lathem, S. A., Neumann, M. D., & Hayden, N. (2011). The socially responsible engineer: Assessing student attitudes of roles and responsibilities. *Journal of Engineering Education*, *100*(3), 444–474.
9. Bielefeldt, A. R., & Canney, N. E. (2016). Perspectives of engineers on ethical dilemmas in the workplace. In *Proceedings of the 2016 ASEE Annual Conference & Exposition*, New Orleans, LA.
10. McCaul, E., Whitlatch, E., & Gustafson, R. J. (2003). Alumni perspectives on professional and ethical responsibility (p. 8.176.1-8.176.14). In *Proceedings of the 2003 ASEE Annual Conference*, Nashville, TN.
11. Colby, A., & Sullivan, W. M. (2008). Ethics teaching in undergraduate engineering education. *Journal of Engineering Education*, *97*(3), 327–338.
12. Burack, C., Duffy, J., Melchior, A., & Morgan, E. (2008). Engineering faculty attitudes toward service learning. In *Proceedings of the 2008 ASEE Annual Conference & Exposition*, Pittsburgh, PA.
13. Liu, S., Zappe, S. E., Mena, I. B., Litzinger, T. A., Hochstedt, K. S., & Gallant, T. B. (2015). Faculty Perspectives About Incorporating Academic Integrity into Engineering Courses. In *Proceedings of the 2015 ASEE Annual Conference & Exposition,* Seattle, WA.

14. Herkert, J. R. (2005). Ways of thinking about and teaching ethical problem solving: Microethics and macroethics in engineering. *Science and Engineering Ethics*, *11*(3), 373–385.
15. Link, A. N., Swann, C. A., & Bozeman, B. (2008). A time allocation study of university faculty. *Economics of Education Review*, *27*(4), 363–374.
16. Shavelson, R. J., & Stern, P. (1981). Research on Teachers' Pedagogical Thoughts, Judgments, Decisions, and Behavior. *Review of Educational Research*, *51*(4), 455–498.
17. Lattuca, L. R., & Stark, J. S. (2009). *Shaping the college curriculum: Academic plans in context* (2nd ed). San Francisco, CA: Jossey-Bass.
18. Emirbayer, M., & Mische, A. (1998). What is agency? *American Journal of Sociology*, *103*(4), 962–1023.
19. Stephan, K. (1999). A survey of ethics-related instruction in U.S. engineering programs. *Journal of Engineering Education*, *88*(4), 459–464.