

Social Responsibility in Engineering Education and Practice: Alignments, Mismatches, and Future Directions

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Student learning about engineering and corporate social responsibility: A comparison across engineering and liberal arts courses

Abstract

The growing literature examining engineering students' attitudes and learning about social responsibility focuses on the professional and personal dimensions of engineers' responsibilities [1]–[4]. Knowledge of how engineering students understand the contested and controversial field of corporate social responsibility (CSR), including its intersections with those other domains of responsibility and the potential tensions that exist among them, is less well developed. This paper addresses that gap by analyzing the first year of research assessing the introduction of CSR-themed content into courses at three universities: Colorado School of Mines, Virginia Tech, and Marietta College.

In this paper we offer a preliminary analysis of the pre- and post-module survey responses of over 600 students in targeted mining engineering, petroleum engineering, design, and liberal arts courses, tracking changes in the students' knowledge, attitudes and skills about CSR and its relation to engineering. Among the courses, we identify differences in the extent to which the classes of students: 1) improved in defining CSR and identifying historical trends in its development; 2) broadened their understanding of stakeholders to include oppositional groups; 3) believed that CSR would be relevant to their careers as engineers; and 4) considered that training in CSR had enhanced their interest in engineering ethics more broadly. We offer preliminary thoughts on the main causes of those differences, including course content and context, instructor background, and length and depth of the CSR modules. Finally, we conclude by tying our research back to the existing work on engineering students' attitudes and learning about social responsibility more generally.

1. Introduction

CSR is a controversial concept, and interpretations of CSR are deeply informed by one's personal and political views [5]. Proponents of CSR, for example, view it as a vehicle for transforming businesses to create shared economic, social and environmental value for themselves and their stakeholders. In contrast, some skeptics from inside of the business world view CSR as an intrusion on free market principles (see [6] for an early and famous example). And critics of capitalism in general argue that CSR allows corporations to capture and reframe social problems "in such a way as to align with the agendas of corporations and make them amenable to the interests of big business" [7].

Despite these varying assessments of CSR from both the academy and business world, it remains a dominant organizing framework for debating the responsibilities of businesses to their stakeholders and to society. It is difficult to find a for-profit enterprise that does not commit itself in some way to higher ideals of responsible practice, even if those promises are made in instrumental ways (such as to increase profitability by mitigating social risk) or can be questionably or unevenly realized in practice. Given that the majority of engineers in the US work for corporations, they must therefore navigate CSR as an area of practice in their own professional lives.

Our initial review of the academic literature in engineering education, however, found that CSR has played little to no role in undergraduate engineering ethics education [8], [9]. These activities instead tend to present engineers as individual agents who weigh decisions based on professional codes [10]–[12]. Elsewhere the first two authors of this article hypothesize that this fissure between engineering ethics and CSR could be due to the historical evolution of engineering ethics education [13]. This emerged as a counterweight to corporate power, with the goal of protecting professional autonomy. In this vein, CSR would likely be considered to be one of the sources of corporate power to be guarded against rather than an arena in which engineers can make ethical judgments and exercise ethical practices.

With funding from the National Science Foundation's Cultivating Cultures of Ethical STEM program (Award 1540298), the research team has been integrating CSR content into targeted courses in petroleum engineering, mining engineering, design, and the liberal arts at the Colorado School of Mines, Marietta College, and Virginia Tech. As described in greater depth below, those modules range from single assignments and lectures to a course-long, scaffolded case study. The material for the modules draws from existing peer-reviewed literature as well as the researchers' ongoing ethnographic research with engineers who practice in the mining and oil and gas industries. One of the common findings from interviews and conversations is that engineers find themselves ill-prepared to grapple with the CSR dimensions of their careers and have to learn on the fly. One key goal of our work, therefore, is to take those lessons back into the undergraduate curriculum, providing students with real-world, critical perspectives on the relationships among CSR and engineering before they graduate.

A second major goal of the project has been to investigate if and how student knowledge and opinions about CSR change as a result of the modules. The research team, in collaboration with other engineering educators and a panel of industry experts, developed, piloted, and revised an assessment tool that was given to each student enrolled in each of the targeted courses, once at the beginning of the semester and once at the end. The research team originally hoped to be able to make comparisons between and among the courses in order to shed light on the factors leading to the most impactful student learning experiences. The variables among the courses are too substantial to merit such a comparison, given differences in instructor background, course content, type of course (lecture, lab, seminar, etc), module content, module length, student major, student year in college, etc. Moreover, because the course integrations were happening simultaneously, some students were enrolled in more than one targeted course at a time, such as the students taking the upper-division social science Corporate Social Responsibility course at

the same time as the Petroleum Seminar. Given that it would be impossible to control for these variables, this paper instead shares general results for each of the courses and offers preliminary thoughts on the observed differences.

In this paper we analyze pre- and post-module survey responses of over 600 students in targeted mining engineering, petroleum engineering, design, and liberal arts courses, tracking changes in the students' knowledge, attitudes and skills about CSR and its relation to engineering. These results should be considered preliminary, as the research as well as data analysis are ongoing. This paper represents our first effort to identify the main trends happening in each of the courses. As a whole, it is not possible to establish *why* student learning outcomes differed in the courses because there were too many variables. The CSR modules were designed to fit the needs of each particular course, rather than provide a one-size-fits all module. The instructors also varied in their disciplinary backgrounds (ranging from engineering to anthropology), and the courses fulfilled different roles in the students' undergraduate experience (as required courses or as electives), enrolled different students (varying by class year and major), utilized different pedagogical techniques (from project-based learning to seminars to lectures) and covered different material.

Here we offer a broad summary of the key trends we have thus far observed in the data. We report on changes in the class responses as a whole, rather than student-by-student. This information on broad trends provides the foundation for both more detailed statistical analysis and revisions in the survey instrument. Given these limitations, we identify differences in the extent to which the classes of students: 1) improved in defining CSR and identifying historical trends in its development; 2) broadened their understanding of stakeholders to include oppositional groups; 3) believed that CSR would be relevant to their careers as engineers; and 4) considered that training in CSR had enhanced their interest in engineering ethics more broadly. We offer preliminary thoughts on the main causes of those differences, including course content and context, instructor background, and length and depth of the CSR modules. Finally, we conclude by laying out future directions for research and tying our research back to the existing work on engineering students' attitudes and learning about social responsibility to consider the opportunities and pitfalls of integrating CSR into teaching and learning about social responsibility more generally.

2. The courses

The three universities selected for the project—Colorado School of Mines, Virginia Tech, and Marietta College—all have long-standing and large undergraduate programs in mining and/or petroleum engineering, but are located in different regions of the country (West, Midwest and East), have different overall student population sizes (31,000 at VT, 5500 at Mines, and 1200 at Marietta), and place students in different companies and sectors of the extractive industries. The

three institutions also offer a valuable comparison given their institutional approaches to integrating CSR and ethics into the mining and petroleum engineering curriculums. VT stands out in offering a Green Engineering minor that students can pair with Mining Engineering. Professor Emily Sarver has spent the past four years transforming their program into a "leadership-focused" curriculum, an intentional shift to best serve the needs of an industry with ever-increasing demands for socially, environmentally and economically responsible resource development. They aim to explicitly include topics such as ethics, stakeholder engagement, risk management, and continuous improvement within focused coursework, but also to better integrate these topics across the rest of the technical curriculum. CSM has taken two different approaches. First, the school's Humanitarian Engineering (HE) program, the first of its kind in the country, offers a campus-wide lecture series on CSR in extractive industries and students may take the Corporate Social Responsibility course analyzed here to fulfill HE and/or humanities and social science requirements for graduation. Finally, Marietta College is the only liberal arts school in the country that offers an undergraduate degree in petroleum engineering. Engineering students there take a broad array of courses in the liberal arts, including specific courses on ethics.

A summary of the courses analyzed in this paper appears below, along with the number of students from each class who gave informed consent for their survey responses to be included in our research. Response rates varied per course but were generally high, from 65% to 100%.

UNIVERSITY	COURSE TITLE	SUM 16	FALL 16	SPRING 17	SUM 17	TOTAL		
MINES	MINES							
Petroleum Engineering	Petroleum Engineering Field Session	82			68	150		
	Reservoir Fluid Properties		80			80		
	Senior Seminar		195			195		
Mining Engineering	Introduction to Mining			40		40		
Liberal Arts	Corporate Social Responsibility		26	26		52		
	Indigenous Peoples and Natural Resource Development			12		12		
						529		
MARIETTA COLLEGE								
Petroleum Engineering	Engineering, Reasoning, and Ethics		20			20		
						20		
VIRGINIA TECH								
Mining Engineering	Introduction to Mining		40			40		
	Mine Reclamation and Environmental							
	Management			40		40		
						80		
TOTAL STUDENTS GIVING INFORMED CONSENT						629		

STUDENTS GIVING INFORMED CONSENT

The sections that follow describe what we did in each of the courses.

Colorado School of Mines: Petroleum Engineering

Summer 2016 and Summer 2017 Field Session

The petroleum engineering field session course is a required curriculum component for students majoring in petroleum engineering. Taking place over eight days in May between students' sophomore and junior years, the field session is the first course in the petroleum engineering degree program that exposes them directly to companies and field activities, and for many students, it is their first exposure to the oil and gas industry in general. Students are assigned to one geographic site, where they travel with professors and teaching assistants and visit oil and gas fields and facilities. In Summer 2016 and Summer 2017, those sites included California, Texas, Wyoming and North Dakota. The field sessions are characterized by intense activity and togetherness, as students and faculty spend up to 12 hours a day together, touring sites and sharing meals and activities.

In Summer 2016, two faculty members from the Liberal Arts and International Studies joined two Petroleum Engineering Field Sessions in California and Texas to incorporate CSR in the curriculum. This included assigned readings for the students, debrief sessions after field tours to discuss CSR practices identified in the daily tours, discussions between students and faculty, and a community meeting where local officials and leaders of independent oil companies discussed the importance of CSR in the community. In Summer 2017, Petroleum Engineering Faculty continued the initiative to bring CSR into the Field Session, but without the faculty from liberal arts in attendance. Similar to Summer 2016, students participated in readings, debrief sessions after field tours to discuss CSR practices identified in the daily tours, discussions between students and faculty, and a community meeting where local officials and leaders of independent oil companies discussed the importance of CSR practices identified in the daily tours, discussions between students and faculty, and a community meeting where local officials and leaders of independent oil companies discussed the importance of CSR in the community. They were assigned the same readings and same assignments as the previous summer.

Fall 2016 Properties of Reservoir Fluids

This required course, taken primarily during students' junior year, introduces the properties of reservoir fluids encountered in petroleum engineering. It is taught by a petroleum engineering professor who holds degrees in both petroleum engineering and law, and who brings professional experience serving as an operations engineer, production engineer, attorney, and international negotiator for oil and gas project development. She is also the Chair of the Society of Petroleum Engineers (SPE) Sustainable Development Technical Section and a member of the SPE Health, Safety, Security, Environment, and Social Responsibility (HSSE-SR) Advisory Committee. In the course, phase behavior, density, viscosity, interfacial tension, and composition of oil, gas, and brine systems are discussed. Course curriculum includes laboratory measurements, interpretation of lab data for engineering applications, flash calculations with k-values and equation of state and an introduction to fluid property software. CSR had previously not been taught in the course, as it focused on the technical curriculum. In Fall 2016, CSR was introduced to the class through one assignment in which students watched a video about Chevron's Alder Gas Field Project and answered questions about Chevron's Health, Safety, Security, Environment and Social Responsibility (HSSE-SR) and Sustainable Development practices.

Fall 2016 Senior Seminar

Petroleum seminar is a required course for all petroleum engineering students that meets once a week for two hours. It is taught by a registered professional engineer who studies engineering education pedagogy. The course is a skills-development seminar in which students practice communication and professional skills, along with looking at how engineering projects/problems are affected by both technical and non-technical issues. One of the major modules presented in the course had the students learn about public perception of the oil and gas industry through

reading and research, listen to speakers versed in CSR, and analyze a case study in which an engineer was placed in the unfamiliar role of dealing with CSR. In the semester reported on here, the PE professor and anthropologists designed a semester-long case study taking students through the CSR dimensions of a major real world oil and gas infrastructure project in Papua New Guinea. Students completed research and writing modules based on the career experiences of a Mines grad who led the project and who came to Mines to provide a lecture and answer student questions at the conclusion of the modules. Activities within the case study sequence included learning about the sustainability performance standards required for major international development; identifying the overlaps and gaps between a major multinational company's CSR policy and those performance standards; evaluating the relationships and tensions among CSR, social license to operate (SLO), and sustainability; reading academic literature on the unique opportunities and challenges of CSR in the oil and gas industry; and a role playing exercise which put the students in a similar decision-making circumstance as the engineer who wrote the case study. There were also underlying CSR themes in other assignments that asked students to consider "multiple aspects" of the issues at hand, but they were not required to look at CSR specifically.

Colorado School of Mines: Mining Engineering

This is a lower-division mining engineering course required for mining majors, but open to other majors as an elective. The course is taught by a mining engineer with industry experience and limited background in CSR. During the second half of the semester, a one-hour lecture introduced basic concepts of CSR and sustainability including common terminology, fundamental tenets (environmental, social, economic) and stakeholder responsibilities. The Jeremy Moon book on CSR [14] was next used as a basis of a follow up one-hour lecture and classroom discussion. During the rest of the semester, nine readings based on CSR were assigned and discussed in the class. Each assigned reading covered a different subject related to CSR and ranged from book chapters to journal articles. The CSR readings were aligned with the technical themes covered in class and included mine design, exploration, mining operations and mine closure and reclamation. Selected homework assignments integrated CSR concepts from the assigned reading material into the technical concepts on mine design, exploration, mining operation, mining operations and mine closure and reclamation.

Colorado School of Mines: Humanities and Social Sciences

Fall 2016 and Spring 2017 Corporate Social Responsibility

This is an upper-division social science and humanities elective taught by an anthropologist who studies CSR in the mining and energy industries. The course is a discussion based seminar, in

which the students read and discussed peer-reviewed social science articles providing a critical take on CSR for case studies of multiple industries, but with a focus on mining and oil and gas. Readings from both courses included: a comparison of two mining projects' engagements with indigenous populations to illustrate the value of cultural relativism; a comparison of two mining projects in Guatemala to understand the significance of human-environment relations for public perception of mining; an ethnographic analysis of the engineering practices that form the basis for compensation agreements in a South American mining project; a critique of Chevron's community development efforts in Bangladesh; an analysis of 'good neighbor agreements' in a controversial mine project: a critique of disconnects between community relations personnel and engineers in an African mining company; an analysis of why environmental initiatives often meet with more success than social ones in the oil and gas industry; and a critique of how focus on the social license to operate in the mining industry can hamper sustainable community development efforts. Guest speakers came from industry, from consulting firms that focus on community engagement, and from academia. For their final essays, students synthesized the semester's reading to critically analyze the potential for CSR to deliver shared social, environmental, and economic value to stakeholders. In groups, they gave presentations on the articles, lead one class discussion, and created a stakeholder engagement plan for a real world engineering project. The course focused primarily on the community engagement dimensions of CSR, with gestures to the role played by engineers and engineering.

Spring 2017 Indigenous Peoples and Natural Resource Development

This is an upper division elective humanities and social science class taught by an anthropologist in the Mining Engineering Department who has studied indigenous peoples and mining. The class is taught using a discussion-based format, in which students read peer-reviewed articles, an ethnography, and UN and other agency reports. The CSR-specific content included the free, prior and informed consent; the rights of indigenous peoples; environmental and social impact assessments; and cultural resource management. Students are expected to synthesize the material through both oral and written forms and engage in daily discussions. Interactive activities such as an interactive debate about the Dakota Access Pipeline and the negotiation simulation encourage them to think critically about contemporary issues and build their skills in research, active listening, and formulating an argument.

Marietta College: Petroleum Engineering

Fall 2016 Engineering, Reasoning and Ethics

This is a first-year seminar course for students who have declared and been accepted into the petroleum engineering major. It is team taught by three professors, each of whom are petroleum

engineers and one of whom is also a licensed attorney. The course provides students with an overview of energy production and of engineering in upstream oil and gas operations. Students learn to reason through complex engineering issues by application of critical thinking skills. Specific student learning outcomes for this course include increased understanding and application of critical thinking skills and an increased awareness of the ethical implications often associated with decision making.

The course is unique in that it also must tie into the Marietta first year common experience, with a shared book that is not directly tied to petroleum engineering. In this iteration of the course, the professors used the book to encourage students to think about what responsibilities are. They also taught John Turley's influential book evaluating the Macondo blowout to segue from personal responsibility to organizational or corporate responsibility. In one of the assignments, students were instructed to analyze a 'technical' engineering document from a professional journal that has social responsibility implications and analyze: the main purpose; the key questions; the most important information; the main inferences and conclusions; key concepts; main assumptions in the author's thinking; implications of taking and not taking the author's line of reasoning seriously; the main points of view; the social responsibility issue and the means to address it; and the ways in which the social responsibility issue could influence their future work as a petroleum engineer.

Virginia Tech: Mining Engineering

Fall 2016: Introduction to Mining and Minerals Engineering

This is a sophomore-level required course for all mining engineering majors at Virginia Tech, with occasional participation by non-majors as an elective. The instructor in the fall 2016 semester was a post-doctoral associate with some mining industry experience between BS and post-graduate degrees all in mining engineering. The instructor did have some research experience related to sustainability, but not CSR specifically. The instructor taught the course using the syllabus designed by a professor of mining engineering who is the primary course instructor. It is the first in-major course that mining engineering students take and serves as a broad introduction to key topic areas in the field (e.g., mineral exploration and reserve estimation, feasibility analysis and mine development, surface and underground mining techniques, unit operations for mineral processing, health and safety in mining, environmental management of mine sites), which generally covered through a series of interconnected modules.

The course has been designed with broader impacts – including social, environmental, health and safety, and economic – of mining/resource extraction as an overarching theme. Sustainable development (SD) and CSR are explicitly introduced in the first course module on mining and

society as soft "threshold concepts", with the idea that students will begin their studies of mining engineering with some foundational knowledge in this domain. These concepts are revisited throughout the course in all subsequent modules, including through associated discussion points in class (e.g., potential social impacts of various mining methods), as the basis for analysis of engineering design work on computational assignments (e.g., the influence of particular design parameters on measures of environmental quality), and in several specific assignments (e.g., critical analysis of CSR practices by certain companies in consideration of site-specific circumstances).

Spring 2017: Mine Reclamation and Environmental Management

This is a senior-level required course for all students majoring in mining engineering at Virginia Tech. The instructor in the spring 2017 semester was a PhD candidate - BS and MS degrees in mining engineering. The instructor had actually taken this course as an undergraduate, and was taught by primary course instructor at that time. As indicated by the title, this course was born (in the late 1990s) out of an effort to explicitly incorporate environmental topics into the mining engineering curriculum. As such, the course covers environmental law and regulation, liability, permitting requirements and technical content related to environmental control at mine sites (e.g., basic hydrology, aqueous chemistry, and soil physiology and mechanics). The course has evolved in the past decade or so to also emphasize a number of social/socio-environmental topics including those essential to CSR and, more broadly, sustainable development (e.g., stakeholder identification and engagement, conflict management, sustainability reporting, management theory, and ethics). These topics are taught using a mix of in-class discussion and activities and out-of-class assignments based on specific reading material and/or video content. The course also includes a field trip that provides opportunities for students to talk directly with members from various stakeholder groups in the VA coalfields including state regulators, industry members and local citizens.

3. Survey

Appendix A includes the survey instrument used in the first year of the study analyzed here. It was designed to measure students' knowledge, abilities, and attitudes [15] related to CSR and collect relevant background information to explore possible connections between those and the demographic information, students' motivations for pursuing engineering, their career desires, and their civic activities. The survey reflects feedback from an expert panel of engineering educators and industry practitioners, as well as "talk alouds" with students. Going through the first year of survey data revealed limitations of some of the questions, which were revised for the second year of courses but not included in this paper.

4. General results

As stated in the introduction, there exist too many variables to establish *why* student learning outcomes differed in the courses. The CSR modules were designed to fit the needs of each particular course. The courses were taught by professors from different disciplinary backgrounds (such as engineering to anthropology), fulfilled different roles in the students' undergraduate experience (as required courses or as electives), enrolled different students (varying by class year and major), utilized different pedagogical techniques (from project-based learning to seminars to lectures) and covered different material.

Here we offer a general summary of the broad trends we have thus far observed in the data. We report on changes in the class responses as a whole, rather than student-by-student. In future research we will be conducting a paired t-test to determine statistical significance of the data we present below.

What is corporate social responsibility?

This is the first question on the assessment and is an open-ended response. Using a rubric developed by the research team, the responses were graded as 2 (demonstrating the social, environmental and economic dimensions of good business practice), 1 (referencing at least 2 of these dimensions) or 0 (does not address any facet of the definition). Primary coding was done by one undergraduate researcher after being trained by the first author and going through the process of normalizing the coding.



Observations

• Marietta's *first-year* course on engineering ethics and reasoning and Mines' *senior* petroleum engineering seminar showed the greatest improvements. While the Mines students were about to complete their undergraduate curriculum, they had not had

specific CSR content, meaning that the modules were the first in-depth treatments of CSR for both groups.

- Virginia Tech's sophomore Intro to Mining course also showed substantial improvement. In contrast, Mines Intro to Mining sophomores entered with already sophisticated ability to define CSR, even though had no prior CSR-focused coursework. They would have been exposed to one CSR lecture (delivered by the first author) in their required first year environmental ethics and writing course, but that learning was not specifically assessed in a course assignment or survey. The Virginia Tech students would have taken two first year engineering courses that cover engineering ethics and broad (including social) impacts of certain engineering work.
- Virginia Tech's seniors in the Reclamation and Environmental Management course entered with advanced ability to define CSR. CSR and sustainable development are specifically covered in the sophomore Introduction to Mining course (designed by the same primary instructor), and these are directly or indirectly covered to some extent in a number of other courses within the mining engineering curriculum. Coming into this course, students have some real experience and knowledge to draw on that is specific to mining. Nearly all students have participated in at least one practical work experience (internship, co-op) by the time they take this course and they are generally able to use common terminology in the realm of CSR and SD, and can offer specific examples of CSR practice and discuss efficacy or success.

What is the social license to operate?

This is the second question on the assessment and is an open-ended response. Using a rubric developed by the research team, the responses were graded as 2, 1, or 0. Primary coding was done by one undergraduate researcher after being trained by the first author and going through the process of normalizing the coding. To receive a two, responses had to signify that the term encompasses community acceptance. If students said that a social license to operate was an actual permit or license that could be given or taken away, they were given a 1 since the social license is more ephemeral.



Observations

• These results do not seem to vary in the same way that the results for defining CSR do, which might suggest that these two kinds of knowledge are not necessarily tied to each other. This is intriguing because the social license to operate is often portrayed as a 'threshold' concept for CSR, but it does not seem to be for these students.

Who is a stakeholder?

The survey asked students to check yes, no or I don't know to respond to the question: According to scholars and practitioners of CSR, corporations have responsibilities to: Their shareholders; their employees; local communities; society at large; suppliers; customers; government agencies; civil society (including NGOs); activists opposed to their industry; and future generations. The goal of the question was to see how broad the students' understanding of a stakeholder was. While the responses to most of the categories did not change (i.e. they were equally likely to identify employees in both pre and post surveys), the category that showed the most difference was that of activists opposed to their industry. Out of all of the stakeholder groups, students at the beginning of the courses were the least likely to consider activists as a group to which corporations have responsibilities. In some but not all of the courses, that opinion changed dramatically:



Observations

- The biggest jump came in the 2016 Field Session, which was co-facilitated by an anthropologist who ensured that topics and questions surrounding CSR were integrated into the site visits and discussions among the students. A much smaller jump was observed in the 2017 Field Session, which used the same material but did not include a social scientist on the trip.
- Almost all students in the social science CSR course and the Reclamation and Environmental Management course ended the semester by recognizing the responsibilities corporations had to activists.
- The question did not ask students about their *personal* opinions about whether activists were stakeholders, but whether scholars and practitioners of CSR considered them to be. The question therefore does not tell us much about students' own opinions about this inclusion of activists as stakeholders.

How has CSR changed over time?

To test students' understanding of current best practices in CSR and how those have changed over time, we asked students the following question:

6. How has corporate social responsibility changed over time?

- Companies put the most efforts into CSR in the 1970s when the environmental movement was strong, but CSR has since diminished in importance.
- The federal government has established more rigorous laws governing corporate treatment of communities.
- Companies are increasingly placing scholarships and other charitable donations at the center of their CSR efforts.
- Corporate commitments to CSR have resulted in companies changing core business practices to better serve their stakeholders.

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None of the above
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I don't know

The correct answer is the fourth one. The question was designed to test if students could recognize that:

- CSR has become increasingly important in the corporate world
- No federal regulations exist to set out requirements for community engagement
- Companies are moving away from philanthropy to change core business practices.



Observations

- There was a significant jump in the 2016 Field Session, in which students had an opportunity to tour oil and gas facilities first hand and ask company engineers and representatives about how and why they practice CSR. No noticeable jump was evident in the following summer.
- Courses that provided historical content for CSR and related activities, such as the CSR course and Reclamation and Environmental Management, showed substantial jumps.
- The seminar course in which students were tasked with a role playing exercise to "do" CSR themselves also showed a substantial jump in ability to identify the correct answer.

Will CSR affect my career as an engineer?

Seeking to gauge the extent to which students saw CSR as relevant to their careers as engineers, we asked them how probable it seemed to them that they would encounter CSR in their careers as engineers.



Observations

- The incoming cohorts of petroleum engineering sophomores expressed dramatically different opinions, with half of 2016 students responding "very probable" but almost 100% of the 2017 students responding "very probable." Before this course, students have had only one petroleum engineering course (Rock Properties) that does not include CSR content. A few explanations of this difference are possible: 1) worsening market conditions in the oil and gas industry led to lower numbers of students in 2017 (about 130 instead of 180), perhaps selecting only those who were passionate about the field or who had family experience in it or 2) the highly publicized 2016 controversy over the Dakota Access Pipeline was well known to the 2017 students and convinced them of the importance of CSR.
- Almost all of the students at Marietta (first years only) and Virginia Tech (sophomores and seniors) saw the relevance of CSR to their careers at the beginning and end of the semesters, whereas the students at Mines were more mixed.

Has CSR enhanced my interest in engineering ethics?

One of the hypotheses of our research was that CSR would enhance students' interest in engineering ethics, as it would provide concrete professional dilemmas that drew attention to the inherent sociotechnical nature of engineering work. The first version of the survey asked students the extent to which they agreed with the statement that attention to CSR increased their interest in engineering ethics. Recognizing the limitations of this framing (as students in the "pre" surveys had sometimes not yet been exposed to CSR content), we amended the question in the

next survey iteration to ask the students to rank their interest in engineering ethics so that we could compare those rankings at the beginning and end of the semester.



Observations

• There is a wide variety in the courses, though most show upticks in students who 'strongly agree' or 'agree' that CSR has increased their interest in engineering ethics. The only course in which there was no disagreement or uncertainty was the Summer 2016 field session.

4. Limitations, future directions and conclusion

As we will continue this research for three more years, we have opportunities to continue this analysis and make improvements to make the results more broadly valuable. This includes revising the original survey instrument whose results are analyzed in this paper.

Survey instrument revisions

Our analysis of the first year results of the study revealed several limitations of the survey instrument that we revised for the second year of the study. Specifically:

- We developed and implemented questions that would allow students more space to provide critical analysis of the limitations of CSR and social license to operate rather than simply defining these terms and identifying good examples of them.
- We revised questions to provide more nuance in student opinions. Rather than ranking stakeholders, corporate priorities, or engineering responsibilities on a scale, we used Likert scales to understand the relative importance of each of those things. For example, instead of having students rank an engineer's responsibilities in a set order, we included a

question that allowed them to evaluate each kind of activity, and distinguish whether the activity should be done by engineers all the time, when possible, by someone in a company other than an engineer, or not at all.

Further, the student scores on the survey will be analyzed more deeply in order to assign significance to the impact of the course intervention. Rather than analyzing changes in the courses as wholes, we will be analyzing student-by-student changes.

Opportunities and pitfalls of using CSR as a vehicle for teaching about social responsibility

The significant diversity in the courses, CSR modules and instructors guards against any generalizations. The courses included seminars, lectures, and an intensive field session. Some professors inserted CSR into a few lectures and course assignments, while others weaved CSR content throughout the entire course. We also note diversity among the students themselves, as they entered the courses with different backgrounds as well as knowledge and opinions about CSR. These results are, however, transferrable to many different contexts. Many engineering educators will identify with some component of the many different modes for delivering instruction in CSR. While further analysis will tease out specific comparisons, our initial results show that:

- Students in all of the courses improved in defining CSR, especially in recognizing its social, environmental and economic dimensions. Most also improved in identifying historical trends in its development.
- A majority of students (between 50% and 100% depending on the course) broadened their understanding of stakeholders to include oppositional groups, which could signal a greater openness to understanding perspectives other than their own and responding to a wider array of concerns.
- A strong majority of students (between 70% and 100% depending on the course) ended the modules believing that CSR would be relevant to their careers as engineers, potentially upsetting a technical/social dualism that could otherwise separate engineering and CSR.
- The majority of students (between 60% and 100% depending on the course) ended the modules with a greater interest in engineering ethics.

Within the larger, recent body of research on engineering students' changes in attitudes about social responsibility over time, these interventions are encouragement for faculty to continue integrating SR with their courses. Previous studies point to the influence of individual courses on SR attitudes, but a relatively small number of students actually had an impactful experience in a class [16]. These types of interventions in the classroom have the potential to battle a culture of disengagement [17], address the overall narrowing from macroethical to microethical attitudes

about engineers' professional responsibilities [18], [19], and even retain more students with prosocial motivations to enter the engineering profession [20].

In the specific case of this research, it is promising that the diversity of course content, instructors, and depth and length of the CSR modules all seem to lead to students who are more able to engage CSR as a concept with direct relevance to their careers. Given the prevalence of CSR in the business world as a framework for understanding relationships between companies and their stakeholders, it is crucial that engineering students enter the workforce prepared to engage that concept in constructive yet critical ways. In future work, we seek to gain a finer-tuned understanding of which kinds of course activities, delivered at which point in students' undergraduate education, are most effective for student learning.

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APPENDIX A: SURVEY

1. What is Corporate Social Responsibility?

2. What is the Social License to Operate?

3. Do you agree that engineering plays a role in promoting the:

	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
Profitability of companies	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
Protection of local ecosystems	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
Environmental sustainability of society	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
Economic development for communities	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
Well-being of communities	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
Welfare of society as a whole	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc
A company's reputation	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc

4. According to scholars and practitioners of corporate social responsibility, companies have responsibilities to:

	Yes	No	I don't know
Their shareholders	\bigcirc	\bigcirc	\bigcirc
Their employees	\bigcirc	\bigcirc	\bigcirc
Local communities	\bigcirc	\bigcirc	\bigcirc
Society at Large	\bigcirc	\bigcirc	\bigcirc
Suppliers	\bigcirc	\bigcirc	\bigcirc
Vendors	\bigcirc	\bigcirc	\bigcirc
Customers	\bigcirc	\bigcirc	\bigcirc
Government Agencies	\bigcirc	\bigcirc	\bigcirc
Civil Society Organizations (Such as non-governmental organizations)	0	0	0
Activists opposed to their industry	\bigcirc	\bigcirc	\bigcirc
Future generations	\bigcirc	\bigcirc	0

5. Which of the following practices would be an example of corporate social responsibility?

	This is an excellent example of CSR	This is an OK example of CSR	This is not CSR	l don't know
A company providing training for members of a local community to open their own small businesses	0	0	0	0
A team of engineers redesigning an industrial process to minimize potential spills of hazardous materials	0	0	0	0
A company giving college scholarships to children in the community where they operate	0	0	0	0
A company accurately and transparently reporting its expenditures in another country	0	0	0	0
A company setting up a grievance process where the public can express their concerns and have them appropriately addressed by company employees	0	0	0	0
Employees doing charity or volunteer work in their free time	\bigcirc	0	\bigcirc	0
A company constructing a municipal wastewater treatment plant for a city without one, so that it can reuse the treated wastewater in its own production	0	\bigcirc	0	0
An engineer reporting an unsafe practice to management or government authorities	\bigcirc	\bigcirc	\bigcirc	\bigcirc
A company prioritizing local residents when making hires for new jobs	\bigcirc	\bigcirc	0	0
An engineer changing the route of a pipeline to appease community desires even though it will cost the company more money	0	0	0	0

0. HOW Has corporate social responsibility changed over	6.	How has	corporate	social	responsibility	/ changed	over time	?
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- Companies put the most efforts into CSR in the 1970s when the environmental movement was strong, but CSR has since diminished in importance.
- The federal government has established more rigorous laws governing corporate treatment of communities.
- Companies are increasingly placing scholarships and other charitable donations at the center of their CSR efforts.
- Corporate commitments to CSR have resulted in companies changing core business practices to better serve their stakeholders.
- None of the above
- I don't know

7. Which industries have played the most significant role in establishing best practices in CSR? Check as many as apply.

Petroleum
Mining
Renewable Energy
Manufacturing
Transportation

8. How would you rank the importance of each of the following for a for-profit company? Please rank with 1 being the most important and 7 being the least important

Health of employees
Health of local communities
Economic development of local communities
Safety of industrial processes
Security of a company, its employees, and capital
Environmental performance
Positive reputation

9. In your view, to whom do corporations have the MOST responsibilities? Please rank with 1 being the most responsibility and 11 being the least responsibility.

Their shareholders
Their employees
Local communities
Society at large
Suppliers
Contractors
Customers
Government agencies
Civil society organizations (such as non-governmental organizations)
Activists opposed to their industry
Future generations

10. To what extent do you believe that the practice of CSR helps businesses serve society?

	Neither agree or				
	Strongly Agree	Agree	disagree	Disagree	Strongly disagree
CSR makes it possible for businesses to make a profit while protecting the environment and promoting community development	0	0	0	$^{\circ}$	0
CSR is useful for increasing community acceptance of a corporation, but it does not actually promote a community's wellbeing.	0	0	\bigcirc	0	\bigcirc
CSR is not effective for promoting the financial bottom line of a company or the wellbeing of its stakeholders.	0	0	0	0	0
Businesses should not have to serve society.	\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc

11. To what extent would a company's approach to corporate social responsibility impact your decision to work for them?

Very likely	Somewhat likely	Neutral	Somewhat unlikely	Unlikely
\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc

12. Do you think that you will deal with CSR in your career?

Yes	0
No	\bigcirc
Maybe	\bigcirc
I don't know	\bigcirc

13. Studying corporate social responsibility has increased your interest in the ethical dimensions of engineering.

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
\bigcirc	\bigcirc	\bigcirc	\bigcirc	\bigcirc

BACKGROUND INFORMATION

14. Which of the following were the most influential in your choice of engineering or applied science as a major? Please rank with 1 being the most influential and 7 or 8 (depending if you mark "other") being the least influential.

Earn a high salary
Have job security
Promote the public welfare
Serve communities in need
Solve the biggest challenges facing society
Use my skills in math and science
Follow family advice
Other

15. If you marked "other" in your previous answer, please specify.

16. Have you encountered corporate social responsibility in one of the following areas?

	Yes	No	N/A
Engineering ethics course	\bigcirc	0	\bigcirc
Social science or Humanities course	\bigcirc	\bigcirc	\bigcirc
Technical course in my major	\bigcirc	0	\bigcirc
Technical course outside of my major	\bigcirc	0	0
A course that involves both engineering and social science	0	0	0
Design course	\bigcirc	\bigcirc	\bigcirc
Internship	\bigcirc	\bigcirc	\bigcirc
Research experience	\bigcirc	\bigcirc	\bigcirc

Other (please specify):

17. What is your year in school?

18. What do you see yourself doing 10 years from now?

19. What is your gender?

- Female
-) Male

20. What is your age?

- 21. Please check which ethnicity you identify with
- O White
- Black or African-American
- American Indian or Alaskan Native
- Asian
- Native Hawaiian or other Pacific Islander
- From multiple ethnicities

Other ethnicity (please specify):

22. What is the highest level of school your mother completed or the highest degree she received?

- Less than high school degree
- High school degree or equivalent (e.g., GED)
- Some college but no degree
- Associate degree
- Bachelor degree
- Graduate degree
- 23. What is the highest level of school your father completed or the highest degree he received?
- Less than high school degree
- High school degree or equivalent (e.g., GED)
- Some college but no degree
- Associate degree
- Bachelor degree
- Graduate degree
- 24. In which of the following civic activities do you regularly participate?
- Voting
 Volunteering
 Reading or listening to the news
 Belonging to a campus organization
 - Belonging to a community organization

Other (please specify):

25. Would you be willing to be contacted for a follow-up interview on topics related to engineering and CSR? If so, leave your name and email address here: