Critical Approaches to CSR as a Strategy to Broaden Engineering Students' Views of Stakeholders

Dr. Jessica Mary Smith, Colorado School of Mines

Jessica M. Smith is Associate Professor in the Engineering, Design & Society Division at the Colorado School of Mines and Co-Director of Humanitarian Engineering. She is an anthropologist with two major research areas: 1) the sociocultural dynamics of extractive and energy industries, with a focus on corporate social responsibility, social justice, labor, and gender and 2) engineering education, with a focus on socioeconomic class and social responsibility. She is the author of Mining Coal and Undermining Gender: Rhythms of Work and Family in the American West (Rutgers University Press, 2014), which was funded by the National Science Foundation and National Endowment for the Humanities. In 2016 the National Academy of Engineering recognized her Corporate Social Responsibility course as a national exemplar in teaching engineering ethics. Professor Smith holds a PhD in Anthropology and a certificate in Women's Studies from the University of Michigan and bachelor's degrees in International Studies, Anthropology and Latin American Studies from Macalester College.

Dr. Greg Rulifson P.E., Colorado School of Mines

Greg currently teaches in Humanitarian Engineering at CSM. Greg earned his bachelor's degree in Civil Engineering with a minor in Global Poverty and Practice from UC Berkeley where he acquired a passion for using engineering to facilitate developing communities' capacity for success. He earned his master's degree in Structural Engineering and Risk Analysis from Stanford University. His PhD work at CU Boulder focused on how student's connections of social responsibility and engineering change throughout college as well as how engineering service is valued in employment and supported in the workplace.

Ms. Cassidy Laurel Grady, Colorado School of Mines

Cassidy is currently a junior attending Colorado School of Mines. She is majoring in Geological Engineering and minoring in Engineering for Community Development. Cassidy is interested in working with vulnerable communities on participatory methods of geological risk mitigation and conservation of groundwater.

Dr. Nicole M. Smith, Colorado School of Mines

Dr. Smith is an Assistant Professor in the Mining Engineering Department at the Colorado School of Mines. She is a cultural anthropologist with research and teaching interests in livelihoods and extractive industries, corporate social responsibility, indigenous peoples, artisanal and small-scale mining, and engineering education.

Dr. Linda A. Battalora, Colorado School of Mines

Linda A. Battalora is a Teaching Professor in the Petroleum Engineering Department, a Payne Institute for Earth Resources Fellow, and a Shultz Humanitarian Engineering Fellow at the Colorado School of Mines (Mines). She holds BS and MS degrees in Petroleum Engineering from Mines, a JD from Loyola University New Orleans School of Law, and a PhD in Environmental Science and Engineering from Mines. Prior to joining the Faculty at Mines, Linda served in various roles in the oil and gas industry including operations engineer, production engineer, attorney, and international negotiator for oil and gas project development. She teaches Properties of Reservoir Fluids, Petroleum Seminar, Field Session, Fossil Energy, Environmental Law and Sustainability, and Corporate Social Responsibility. In addition to teaching in the Petroleum Engineering program at Mines, Linda teaches courses in the Leadership in Social Responsibility, Humanitarian Engineering, Energy minor programs and the Natural Resources and Energy Policy graduate program at Mines. Linda is an active member of the Society of Petroleum Engineers (SPE) Health, Safety, Security, Environment and Social Responsibility (HSSE-SR) Advisory Committee and is Chair of the Sustainable Development Technical Section. She is also a member of multiple professional organizations including the American Society for Engineering Education, Association of International

Petroleum Negotiators, American Inns of Court, American Bar Association, and the Colorado Bar Association. Her research areas include HSSE-SR, Sustainable Development, and the Circular Economy. She is a recipient of the 2018 SPE Distinguished Member Award, 2015 SPE Rocky Mountain North America Region Award for distinguished achievement by Petroleum Engineering Faculty award recipient, and the 2014 Rocky Mountain North America Region Award for distinguished contribution to Petroleum Engineering in Health, Safety, Security, Environment and Social Responsibility award recipient. She is also a SPE Distinguished Lecturer (2019-2020).

Dr. Emily Sarver, Virginia Tech

Emily Sarver is an Associate Professor of mining engineering, and adjunct faculty to civil and environmental engineering, at Virginia Tech. Her teaching and research interests center on responsible resource production, occupational health, and mine environmental monitoring. Dr. Sarver teaches about sustainable development principles and practices for mineral and energy resource projects at the graduate and undergraduate levels.

Dr. Carrie J. McClelland P.E., Colorado School of Mines

Carrie J McClelland is an Associate Teaching Professor at Colorado School of Mines. Carrie is a registered professional engineer with a passion for teaching the next generation of engineers to be well-rounded professionals who consider the technical aspects and the broader effects of their work. Her current research interests include pedagogical interventions in the classroom, including how to best teach technical and professional skills.

Dr. Rennie B. Kaunda , Colorado School of Mines

Dr. Rennie Kaunda is an Assistant Professor in the Department of Mining Engineering at Colorado School of Mines, and a licensed Professional Engineer in the State of Colorado. Prior to joining academia, Dr. Kaunda spent more than 7 years in the mining industry. Dr. Kaunda's areas of expertise are mining geotechnics, including rock mechanics and hydrogeology.

Dr. Elizabeth Holley, Colorado School of Mines

Elizabeth Holley is an assistant professor in the Department of Mining Engineering at Colorado School of Mines, where she specializes in mineral exploration and mining geology. Her research applies geological tools to solve problems throughout the mining lifecycle, and her research group's work is funded by the federal agencies such as National Science Foundation and the National Institute for Occupational Safety and Health, as well as NGOs and mining companies. In addition, Elizabeth and her students work on issues involving pedagogy, science policy, and communities.

Critical Approaches to CSR as a Strategy to Broaden Engineering Students' Views of Stakeholders

1. Introduction

The focus on the "public" in the paramountcy principle – that engineers shall hold paramount the safety, health and welfare of the public – importantly places social responsibility at the center of engineering practice. Yet Deborah Johnson [1] cautions that it also treats the public as a "black box" and "hides all the complexity and diversity in the public" (see also [2]). Indeed, the rhetoric of serving "the public" or "society" may mask the ways in which the artefacts, infrastructures, and processes designed by engineers unevenly distribute benefits and harms among populations and inside of particular communities [3]. This perspective suggests, then, that the ethical practice of engineering requires engineers to go beyond considering how their profession contributes to a broadly construed "public good" to consider its implications for specific groups of people. In this paper, we analyze the extent to which taking a critical approach to corporate social responsibility (CSR) in undergraduate engineering courses at four different universities changed the ways in which engineering students identified potential stakeholders and imagined ways to harness engineering designs to benefit them.

Why CSR? CSR is a highly controversial and internally variegated field of practice that seeks to align firms' economic, social, and environmental practices in order to become more accountable to people and groups outside of them. The contemporary field of CSR – distinguished from earlier periods of corporate philanthropy by firms' willingness to effect concrete changes to core business practice [4] – emerged as one strategy for corporations to respond to the growing criticisms that citizens, civil society groups and government bodies made of their power and behavior. At their base, the practices and policies undertaken under the banner of CSR acknowledge that corporations are responsible for more than producing and distributing profit: they must also seek to create social and environmental benefits while minimizing harms. Importantly, while rhetoric surrounding CSR in corporate material invokes broad categories of "the public, "society," or even "the world," the field was a key innovator and disseminator of stakeholder theory. Attention to stakeholders helps to move analysis from idealized abstractions to the messy complexity of everyday life.

The now commonplace notion of "stakeholders" emerged in the mid-1980s precisely as companies sought to clarify their accountabilities to multiple publics, from people who lived nearby their operations and headquarters to civil society groups that criticized their activities. The American philosopher and professor of business administration R. Edward Freeman pioneered stakeholder theory in his 1984 book *Strategic Management: A Stakeholder Approach* [5]. Its central tenants had already been put into practice by Klaus Schwab, a German-born business professor at the University of Geneva, at the annual Davos Conferences beginning in 1971 [6]. Since its original conceptualization, stakeholder theory has achieved widespread dominance, with its key terms and theories animating even non-business arenas such as the academy and government.

Stakeholder theory and its concepts have rightfully come under fire by social scientists. Some argue that stakeholder theory can unduly simplify the social world, reducing complex and shifting social processes and relationships of power into neat boxes of internally homogenous "stakeholders" with clearly defined relationships among them and the company [7]–[9]. Moreover, calling a critical group a "stakeholder" can serve to politically neutralize them and encompass their criticism inside of a company's accountability-making [10], [11]. Finally, the "stakeholder" category does not hold the same sense of rights and obligations as others, such as citizens or rights holders [8], [12]. Yet the language of stakeholders has permeated many areas of engineering education; as of January 25, 2019, a search for "stakeholder" in the ASEE PEER repository returned 2,891 hits.[1] This ready update is likely partially attributable to the corporate context of much engineering practice, but perhaps also because it provides a concrete strategy for engineers to consider how their work is intertwined with the wellbeing of multiple others.

In this paper, we investigate how and to what extent critical instruction in CSR shaped the ways in which mining and petroleum engineering students identified stakeholders and imagined strategies to harness engineering to benefit them. The teaching activities were undertaken between Fall 2016 and Spring 2018 at four different schools: Colorado School of Mines, Virginia Tech, Marietta College (Ohio), and the South Dakota School of Mines & Technology. The research was sponsored by a Cultivating Cultures for Ethical STEM grant from the National Science Foundation, and the details of the project are available in our previous publications [13]–[15].

This paper builds on our preliminary analysis of the survey data we collected to assess changes in students' knowledge, opinions, and abilities related to CSR and engineering. We previously identified the main trends happening in each of the courses [15]. In general, students improved in defining CSR and recognizing its social, environmental and economic dimensions. A majority (between 60% and 100%, depending on the class) also broadened their understanding of stakeholders to include oppositional groups, expressed greater belief that CSR would be relevant for their work as engineers, and expressed a greater interest in engineering ethics. While that analysis was done on class-by-class basis, tracking changes in the class as a whole, this paper analyzes changes on a student-by-student basis. Moreover, in this paper we focus on two specific survey questions that shed light on student thinking about stakeholders and how their work as engineers might engage them.

2. Methods

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. After the first year of survey data was collected and analyzed, and talk alouds were conducted with students who had taken the survey, the team made changes to the assessment instrument to open up more and clearer spaces for students to criticize CSR. This paper reports on only those classes that used the revised survey instrument.

[1] References to "stakeholders" in the ASEE PEER repository also seems to be rising steadily, from 7 in 1996 to 91 in 2006 and 307 in 2017.

For each class, we included only students who gave informed consent and took *both* the pre- and post-course surveys. We listed what percentage of students met our criteria out of each class in the P for participation column.[2] We assigned each student a unique ID to match their pre- and post-course surveys. We then conducted paired t-tests, the Wilcoxon Signed-Rank tests for the non-parametric samples, and calculated the effect size to determine if the changes in student-by-student responses observed over the course of the modules were statistically significant. The questions below had different options, and the most appropriate significance tests combined with the effect size showed us where the most meaningful changes occurred in each class [16]. We used the Microsoft Excel t-test function and the Matlab 'signrank' function to determine the p values with a significance level of 0.05.

Table 1: Course and student summary

UNIVERSITY	COURSE TITLE	FALL 16	P%	SPRING 17	P%	SUM 17	P%	FALL 17	P%	SPRING 18	P%	TOTAL
COLORADO SCHOOL OF MINES												**319**
Petroleum Engineering	PE Field Session					68	100%					68
	Reservoir Fluid Properties							38	100%			38
	Senior Seminar	28	14%					78	53%			106
	Mechanics of Petroleum Production?									15	25%	15
Mining Engineering	Introduction to Mining			18	69%							18
	Earth Materials							8	22%			8
Liberal Arts	Corporate Social Responsibility			19	70%			17	55%	22	71%%	58
	Indigenous Peoples and Natural Resource Development			8	67%							8
VIRGINIA TECH												**91**
Mining Engineering	Introduction to Mining	38	95%					10	50%			48
	Mine Reclamation and Environmental Management			39	100%					4	14%	43
MARIETTA COLLEGE												**21**
Petroleum Engineering	Engineering, Reasoning and Ethics	21	46%									21
SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY												**12**
Mining Engineering	Advanced Mine Planning									9	53%	9
	Senior Design									3	43%	3
		87		84		68		151		53		
TOTAL STUDENTS GIVING INFORMED CONSENT & COMPLETING PRE & POST SURVEYS												443

In this paper we focus our analysis on particular classes rather than the student pool as a whole for multiple reasons. The students themselves came from different majors and were at different stages in their undergraduate degrees, ranging from sophomores to "super seniors" in their fifth year of coursework. We did not teach the same module or same material in each of the courses because we sought to design the modules for needs of each particular course. The instructors also

[2] The low participation in the Fall 2016 Petroleum Engineering senior seminar at the Colorado School of Mines is due to a loss of data – student names were accidentally saved only on the surveys where students had left personal contact information indicating they were willing to be contacted for a follow-up interview. The Spring 2018 Mine Reclamation & Environmental Management participation rate is low for the same reason.

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. Readers who are interested in a more thorough description of the courses should see (authors blinded 2018).

To address the questions of how students identified stakeholders and strategies for using engineering to benefit them, we focus on two groups of questions: one that asked students to prioritize stakeholders and the other that asked them to rate examples of potential CSR projects.

1. *CSR is a diverse field of practice that varies by industry, location, and company. In this survey we use an umbrella definition for CSR: an approach to business in which companies collaborate with stakeholders to create shared economic, social and environmental value. How would you evaluate the following activities as potential examples of CSR?*

Students then characterized the following examples as being an excellent example of CSR, an okay example of CSR, or not CSR, with the option of selecting "I don't know." The most "correct" answers that aligned with course content were scored with 2 points, acceptable answers were scored with 1, and unacceptable answers were scored with zero. Those values are reproduced here for our readers, but were not included on the survey.

- *A company providing training for members of a local community who want to open their own small businesses (2)*
- *A team of engineers redesigning an industrial process to minimize potential spills of hazardous materials after learning that residents are worried about pollution (2)*
- *A company giving college scholarships to children in the community where they operate (1)*
- *A company accurately and transparently reporting how much money it spends in another country (2)*
- *Employees doing charity or volunteer work in their free time (1)*
- *A company constructing a municipal wastewater treatment plant for a city that desires but does not have one, so that the company can reuse the treated wastewater in its own production process (2)*
- *An engineer reporting an unsafe practice to management or government authorities (1)*
- *A company prioritizing local residents when making hires for new jobs (2)*
- *An engineer changing the route of a pipeline to mitigate community conflict even though it will cost the company more money (2)*

2. *How would you rank the importance of companies engaging each of the following stakeholders as part of their CSR efforts?*

- *Shareholders*
- *Employees*
- *Communities*
- *Society*

- *Suppliers and subcontractors (separated into two distinct categories for Fall 2016)*
- *Customers*
- *Government agencies*
- *Civil society organizations (deleted beginning in Fall 2017)*
- *Activists*
- *Future generations*

In the Fall 2016, Spring 2017 and Summer 2017 courses, students ranked those stakeholders 1-11 with 1 being most important and 11 being least important. However, we received strong feedback from some professors that a strict ranking system, in which students could not rank any of the stakeholders equally, did not accurately represent the kinds of decisions they would be forced to make as professionals: they would try to balance the needs/interests of as many as possible, instead of being forced to choose one over the other. Therefore, beginning in Fall 2017, the question instead asked students to state if each engaging each stakeholder was a matter of "highest importance," "important when possible," or "not important," with the option of selecting "I don't know." Highest importance, important when possible, and not important were scored with 2, 1, and 0 points, respectively.

3. Changes in student knowledge and opinions

Given the amount of data, we are not able in this paper to present each theme. Here we focus on three broad preliminary findings.

3.1 Sophomores

The first comparison we can make is among the sophomore students, all of whom were near the beginning of their engineering majors. The second year is a key time for development – choices of major, the last chance to leave engineering, first internships, etc. – but also has been coined the "valley of despair" for many programs with seemingly endless engineering sciences courses often devoid of social and environmental context [17]. The second year has been understudied by engineering educators as the first and final years more commonly have the 'ethics' teaching explicitly, or within design and general education.

We surveyed three courses that mostly enrolled sophomores: Spring 2017 Introduction to Mining (Mines), Fall 2016 and Fall 207 Introduction to Mining (Virginia Tech), and Summer 2017 Petroleum Engineering Field Session (Mines). The field session enrolled students who were completing their sophomore year and entering their junior year. The first two are semester-long, classroom-based courses that introduce students to broad key topics in mining engineering and the latter is an eight-day intensive summer course in which students travel out-of-state to active oil and gas regions to tour facilities and talk with company personnel, including about topics related to CSR. There were three distinct groups of students who went to California, Texas, and Wyoming with different instructors and different field sites, but the same readings and assignments. In both Introduction to Mining courses, CSR themes were interwoven throughout the semester to align with the technical content. The field session included debriefing discussions, journaling, and a short reading on CSR [18].

The courses each enrolled different numbers of students, which calls for caution in interpreting the statistical comparison. In the field session that took place in California, for which we have matched data from 38 students, students showed a statistically significant increase in the importance they placed on future generations (mean increased from 7.436 to 6.641, $p = .0283$) and civil society organizations (from 9.026 to 8.231, $p = .0129$) and a statistically significant decrease in the importance they placed on shareholders (from 2.974 to 3.821, $p = .01469$) and contractors (from 5.7769 to 6.897, $p = .0017$). When combined with the students from the other two sites (Wyoming and Texas), the pattern holds with the perceived importance of shareholders and contractors decreasing (2.974 to 3.821, $p = .015$ and 5.769 to 6.897, $p = .002$ respectively) and civil society organizations and future generations increasing (from 9.026 to 8.231, $p = .013$ and 7.46 to 6.641, $p = .028$, respectively). The top two most important categories after the field session were shareholders and employees, the same as before the field session. See Appendix Classes 1 for full details.

The sophomore students in the two Introduction to Mining courses did not show a statistically significant change in how they viewed the importance of stakeholders. At Virginia Tech, we have data for 37 students during Fall 2016. On average, the students ended the semester placing higher importance on employees (3.250 to 2.639) and communities (4.639 to 3.917). This increase in the importance of communities may be partially due to students decreasing the importance they placed on society in general (4.750 to 5.278). In Fall 2017 there was no significant movement in stakeholder importance, though the student sample size was small (only 10). At Mines, the sample size was about half of the large Virginia Tech course (17 students), and the biggest change was that students placed slightly more importance on shareholders at the end of the semester (from 3.765 to 2.882). See Appendix Classes 2 - 4 for full details.

We had hypothesized that the relative importance placed on shareholders would go down as students learned about more stakeholders through their CSR class materials and discussions, but this did not happen across the classes. According to the survey data, the greatest broadening of students' perceptions of stakeholder importance appears to have happened in the field session rather than in the classrooms. We also found this for the Summer 2016 PE Field Session, as we have already reported [14]. Moreover, the field session also saw statistically significant improvements in students identifying excellent examples of CSR (as discussed in greater detail in the next section): redesigning industrial processes, building a water treatment plant, prioritizing local hires, and rerouting a problematic pipeline.

It is not possible to state conclusively why we observed these differences, especially given that the students were pursuing different majors (petroleum versus mining engineering). A few key features of the field session merit consideration that could be tested in future research. The field session places heavy emphasis on students learning from industry practitioners in their places of business, which shifts the voice of authority in the learning environment from the professor to the practitioner. First, it is possible that when the practitioners spoke of the importance of CSR, it was more persuasive to the students than when their professors in the classroom did so. Second, it is possible that when students visit industry facilities, they see them in their concrete local context, close to neighborhoods and businesses, which could underline the importance of engaging external stakeholders. Third, it is possible that the focused nature of field session – in which the students spent upwards of 12 hours a day together and dedicated themselves entirely to

the experience – facilitated an immersive learning experience that was transformative for their learning. Finally, it is possible that the field session students were slightly more experienced and more ready to incorporate broader perspectives into their thinking than their counterparts in the Introduction to Mining courses, since they had already completed their sophomore year instead of being in the middle of it.

3.2 CSR as a sociotechnical practice

We also sought to better understand if instruction in CSR would change how students imagined ways to harness engineering practice to benefit stakeholders. In particular, we wanted to investigate if students would be more likely to identify practices in which stakeholder concerns changed actual engineering decisions and practices as exemplary CSR activities, rather than those that simply redistributed some of the economics earnings of industry to a broader array of people. In so doing, we drew inspiration of Auld et al.'s distinction between "old" and "new" CSR, in which "old" CSR encompasses philanthropy (such as volunteering and charitable donations like scholarships) and "new" CSR refers to activities that change core business practices to create social, economic, and environmental value for stakeholders as well as companies [4]. The question asking students to evaluate CSR practices as being excellent, okay, or not CSR therefore included a range of activities on the old to new scale, from giving scholarships or volunteering (old) to rerouting pipelines or redesigning industrial processes (full text of the question reproduced above).

The category that saw statistically significant positive changes across the most classes was *prioritizing local hiring*. Students were more likely to complete their courses viewing this as an excellent example of CSR in the following classes: Fall 2016 and Fall 2017 Introduction to Mining (Virginia Tech), Spring 2017 Mine Reclamation and Environmental Management, Summer 2017 Petroleum Engineering Field Session, Fall 2017 Earth Materials, and Spring 2018 Corporate Social Responsibility.

TABLE 2: P values and effect sizes for changes in student views of *prioritizing local hires* as a form of CSR.

Course	P value	Effect size	
F16 Intro to Mining (VT)	0.0068	0.4213	
F17 Intro to Mining (VT)	0.0406	0.3644	
SP17 MREM (VT)	0.0336	0.1518	*
SU17 PE FS (CSM)	0.0328	0.2329	
F17 Earth Materials (CSM)	0.0398	0.81	
S18 CSR (CSM)	0.0017	0.8811	

*The relatively low effect size merits caution when attributing the observed changes to the course.

Prioritizing local residents when making hires is an important dimension of CSR, as it ideally contributes to local economic development in the places where mining and petroleum production take place. When hiring local residents, more of the financial gains from those projects are funneled to the communities closest to them. Jobs are often desired by members of communities

in exchange for allowing mining and energy development, and company personnel frequently include local jobs to increase public acceptance of their development projects. The mismatch between community expectations and the realities of how many jobs are available remain a widespread source of frustration for host communities and company employees alike [19].

While hiring locally does potentially more equitably distribute the economic benefits of mining and petroleum development, it does not necessarily constitute a radical change in business practice: the mining and oil and gas companies could continue their core business activities in the same way but with a slightly different workforce.[3] The category of local hiring could therefore represent a compromise in the minds of students, perhaps signaling their beliefs that local communities should receive more economic benefits from industry activities but that businesses do not necessarily need to change their core practices to appease the concerns of those communities. The students' broad preference to imagine excellent CSR in this way suggests a greater comfort with a moderate rather than radical approach to CSR. It can also leave in place a social/technical dualism [20] found in engineering education and practice more generally, as it leaves the core "technical" activities of industry outside the purview of CSR. The preference for the local hiring category, however, also positively suggests that the students are less enchanted by the sometimes paternalistic activities associated with "old" CSR activities. The only course in which the "scholarships" category actually decreased by a statistically significant amount, however, was the Fall 2017 Corporate Social Responsibility social science course (see Appendix Class 6).

That CSR course, however, also reinforced a social/technical dualism in its own way, even though the professor explicitly sought to undo such a dualism in the course. In each offering of the course, students statistically improved in identifying training for local community members to open their own small businesses as an excellent example of CSR. (This also occurred in the Introduction to Mining course at Mines, though with a low effect size.) Small business training is a ubiquitous element of CSR programs as a strategy for promoting local economic development. Yet, like the local hiring category, it does not offer a fundamental revisioning of core business practices. Interestingly, when a professor from the Petroleum Engineering Department taught the CSR course, students were more likely to view rerouting the pipeline as excellent CSR. When the social scientist taught the course, they improved but not in a statistically significant way.

The courses in which students made statistically significant improvements in recognizing the "new" sociotechnical forms of CSR as being excellent were: Summer 2017 Petroleum Engineering Field Session (redesigning industrial processes, building a water treatment plant, and rerouting a problematic pipeline) and the Fall 2016 Petroleum Engineering senior seminar (redesigning industrial processes). The summer field session is already described in detail above. The Fall 2016 PE senior seminar revolved around a semester-long case study that invited students to put themselves in the shoes of an engineer responsible for aligning a major oil and gas company's activities in a developing country with the World Bank and IFC performance standards. The Fall 2017 PE senior seminar, which instead revolved around a semester-long project based learning exercise, did not show the same improvement. See Appendix Classes 9 – 10 for full details.

[3] It could if local people were able to transform those companies from their positions inside of them.

It is difficult to isolate the reasons why students were more likely to view "new" sociotechnical CSR as excellent CSR in those courses. For example, in many of the other courses, students entered already assigning high scores to rerouting the pipeline, meaning that there was less room for measurable improvement to be made. These courses also tended to enroll more experienced students than the field session. One exception is the mining courses at Virginia Tech, in which the sophomores began the classes already viewing the rerouting of the pipeline as excellent CSR. These preliminary results suggest the importance of instructors gauging where their students are when they begin a course to tailor the content to them.

4. **Conclusion**

One of the initial goals of our project was to conduct research that could shed light on the most effective practices for teaching undergraduate engineering students about the intersection of CSR and engineering. In this paper, we have focused specifically on identifying relevant stakeholders and recognizing ways to use engineering practices to benefit them. We remain very cautious in extrapolating "best practices" from our data, given the impossibilities of standardizing courses and pedagogical practices across a wide array of disciplines, instructor backgrounds, student experience levels, and course types. Still, others working to incorporate CSR into their classes can certainly find some useful lessons.

The data presented in this paper raise important insights that could be better tested with future research. First, and most basically, we found that students arrive to classes with a diverse set of beliefs and knowledge about CSR [see also 21], underlining the point that learning opportunities should be tailored to these varied backgrounds. For example, being able to identify a broad array of diverse stakeholders would likely need to precede recognizing "new" CSR practices that transform core business to serve those stakeholders. Each university and class context will require some different types of teaching that align well with the experiences and values of the students.

Second, we found that among sophomore petroleum and mining engineering students, a focused 8-day summer field session seems to have broadened their perspective of relevant stakeholders more than semester-long classroom-based courses did. In future work, we will see if this pattern holds for the following year of their survey data. Another pathway for further fleshing out this preliminary finding would be to administer the survey before and after the mining engineering field session to see if the results were substantially different or similar to those found in the petroleum engineering field session. In future research we can compare the students' survey responses from their courses that took place in the fall semester after the field session, as the concentrated experiential learning could result in greater immediate changes, but not sustained ones.

Third, we found that not all courses were effective in moving students to a place where they recognized CSR as a sociotechnical practice. Students in the social science course tended to prioritize community training as an example of excellent CSR, while many of the engineering courses prioritized local hiring. Neither of those areas of practice necessarily involves changing business activities to become more responsive to stakeholders, and each of those areas of practice tends to focus on either the social or technical extremes of CSR practice rather than

clearly integrating the two. Educators in all disciplines need to continue countering this dualism, and towards changing business activities where engineers do have more power.

In our future work, we will explore the patterns analyzed in this paper over another year of survey data to see if they hold. We will also consider these patterns in light of the other areas of the survey, such as the students' abilities to engage in critical thinking about key terms such as the "social license to operate" and their own perceptions of the extent to which CSR will be a part of their professional practices as engineers.

Appendix: Tables for the courses most discussed in this paper

Class 1: Summer 2017 Petroleum Engineering Field Session											
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.											
	Shareholders	Employees	Communities	Society	Suppliers	Contractors	Customers	Government	Civil Society Orgs	Activists	Future Generations
p-value	0.0147	0.2031	0.4708	0.3021	0.1596	0.0017	0.2132	0.2902	0.0130	0.0688	0.0283
Wilcoxon	0.2555	0.0705	0.4954	0.5808	0.2592	0.0213	0.9214	0.7626	0.1547	0.5183	0.1980
Effect size	0.0147	0.2031	0.4708	0.3021	0.1596	0.0017	0.2132	0.2902	0.0130	0.0688	0.0283
Q5: How would you rate the importance of companies engaging in each of the following as part of their CSR efforts?											
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Setting Up a Grievance Process	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline	
p-value 1-tail	0.1788	0.0129	0.0048	0.0400	0.4271	0.0007	0.0164	0.3853	0.0328	0.0010	
Effect Size	0.1337	0.2773	-0.3422	0.2378	0.0268	-0.4148	0.2515	-0.0448	0.2830	0.4577	

Class 2: Spring 2017 Introduction to Mining (Mines)											
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.											
	Shareholders	Employees	Communities	Society	Suppliers	Contractors	Customers	Government	Civil Society Orgs	Activists	Future Generations
p value	0.3938	0.7531	0.3066	0.0632	0.7909	0.6959	0.4624	0.2967	0.9345	0.6944	0.9193
Wilcoxon	0.2080	0.4653	0.3500	0.0752	0.8953	0.6531	0.3635	0.3192	0.7329	0.6182	0.5057
Effect Size	-0.3042	-0.0962	0.4045	0.4474	0.1049	-0.1020	-0.2182	-0.2115	0.0229	0.1397	-0.0189
Q5: How would you rate the importance of companies engaging in each of the following as part of their CSR efforts?											
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Setting Up a Grievance Process	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline	
p-value 1-tail	0.04808	0.134331	0.028293	0.303646	0.358422	0.015109	0.064994	0.210504	0.271232	0.374593	
Effect Size	0.336113	-0.28054	-0.46134	0.127333	-0.10798	-0.48468	0.507049	-0.21976	0.132249	0.091422	

Class 3: Fall 2016 Introduction to Mining (Va Tech)											
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.											
	Shareholders	Employees	Communities	Society	Suppliers	Contractors	Customers	Government	Civil Society Orgs	Activists	Future Generations
p value	0.4702	0.2116	0.1078	0.3663	1.0000	0.5183	0.1372	0.8272	0.0947	0.2467	0.7465
Wilcoxon	0.4437	0.0919	0.0744	0.4853	0.8900	0.5056	0.4437	0.0919	0.0744	0.4853	0.8900
Effect Size	0.1376	-0.2758	-0.3077	0.1726	0.0000	-0.0955	0.2793	-0.0384	0.3059	0.1994	0.0741
Q5: How would you rate the importance of companies engaging in each of the following as part of their CSR efforts?											
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Setting Up a Grievance Process	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline	
p-value 1-tail	0.4112	0.0844	0.0079	0.1802	0.2436	0.0271	0.2696	0.0917	0.0068	N/A	
Effect Size	0.1704	-0.6267	-0.5106	0.1295	0.1266	-0.3737	0.1156	0.3054	0.4213	N/A	

Class 4: Fall 2017 Introduction to Mining (Va Tech)										
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.										
	Shareholders	Employees	Communities	Society	Suppliers and subcontractors	Customers	Government	Activists	Future generations	
p (t-test)	0.2789	1.0000	0.6783	0.1679	0.1934	0.5911	0.7263	0.5911	0.1679	
Effect size	-0.4243	0.0000	-0.1581	0.4140	0.4743	0.2070	-0.1482	-0.1581	-0.5721	
Q5: How would you rate the importance of companies engaging in each of the following as part of their CSR efforts?										
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline	
p-value 1-tail	0.1717	0.2217	0.2481	0.5000	0.3392	0.3392	0.0034	0.0406	0.2543	
Effect Size	0.3644	-0.6325	-0.3017	0.0000	0.1482	0.1054	2.1301	0.3644	0.3873	

Class 5: Corporate Social Responsibility Spring 2017 (Mines)										
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.										
	Shareholders	Employees	Communities	Society	Suppliers and subcontractors	Customers	Government	Activists	Future generations	
p (t-test)	0.2789	1.0000	0.6783	0.1679	0.1934	0.5911	0.7263	0.5911	0.1679	
Effect size	-0.4243	0.0000	-0.1581	0.4140	0.4743	0.2070	-0.1482	-0.1581	-0.5721	
Q5: How would you rate the importance of companies engaging in each of the following as part of their CSR efforts?										
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Setting Up a Grievance Process	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline
p-value 1-tail	0.1955	0.1955	0.0908	0.0908	0.0908	0.1955	0.5000	0.1955	0.1955	0.2251
Effect Size	-0.8660	0.4330	0.8660	0.8660	-0.8660	0.5222	0.0000	0.5000	-1.0000	0.7746

Class 6: Corporate Social Responsibility Fall 2017 (Mines)										
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.										
	Shareholders	Employees	Communities	Society	Suppliers and subcontractors	Customers	Government	Activists	Future generations	
p (t-test)	0.0486	0.0413	0.5795	0.2156	0.0201	0.1635	0.0289	0.4836	0.3322	
Effect size	-0.6475	-0.4777	0.2425	0.4777	-1.2127	-0.3805	0.6277	0.2425	-0.1885	
Q5: How would you rate the importance of companies engaging in each of the following as part of their CSR efforts?										
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline	
p-value 1-tail	0.0413	0.1661	0.0019	0.2277	0.1661	0.0519	0.1051	0.0519	0.0817	
Effect Size	0.5314	0.1676	-0.9682	0.2058	0.1564	0.5488	-0.3711	0.3127	-0.3542	

Class 7: Corporate Social Responsibility Spring 2018 (Mines)										
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.										
	Shareholders	Employees	Communities	Society	Suppliers and subcontractors	Customers	Government	Activists	Future generations	
p (t-test)	0.2575	0.1035	1.0000	1.0000	0.1348	0.0303	0.4923	0.0312	0.7147	
Effect size	-0.2477	-0.3814	0.0000	0.0000	-0.3480	0.7764	-0.1486	-0.5042	-0.0892	
Q5: How would you rate the importance of companies engaging in each of the following as part of their CSR efforts?										
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline	
p-value 1-tail	0.0008	0.5000	0.5000	0.0009	0.1018	0.0549	0.3023	0.0017	0.0278	
Effect Size	0.9392	0.0000	0.0000	0.8043	-0.3024	0.4343	0.1017	0.8811	0.4220	

Class 8: Earth Materials Fall 2017 (Mines)										
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.										
	Shareholders	Employees	Communities	Society	Suppliers and subcontractors	Customers	Government	Activists	Future generations	
p (t-test)	0.2849	0.5165	#DIV/0!	0.6845	1.0000	0.1970	1.0000	0.4512	0.2849	
Effect size	-0.4231	-0.2729	0.0000	-0.1680	0.0000	-0.4961	0.0000	0.3360	-0.4494	
Q5: How would you rate the importance of companies engaging in each of the following as part of their CSR efforts?										
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline	
p-value 1-tail	0.3659	0.1753	0.2992	0.1425	0.2992	0.1753	0.3813	0.0398	0.0985	
Effect Size	-0.1768	-0.2700	0.2339	-0.4494	0.1498	0.4677	0.1364	-0.8101	0.5040	

Class 9: Fall 2016 Petroleum Engineering Senior Seminar (Mines)											
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.											
	Shareholders	Employees	Communities	Society	Suppliers	Contractors	Customers	Government	Civil Society Orgs	Activists	Future Generations
p value	0.8844	0.2100	0.5450	0.3471	0.6501	0.8707	0.2048	0.1376	0.3043	0.4831	0.5581
Effect Size	-0.0871	-0.2037	-0.0774	-0.2657	-0.1790	-0.1488	0.3705	-0.1711	0.3096	0.1747	0.1543
Q5: How would you rank the importance of companies engaging each of the following stakeholders as part of their CSR efforts?											
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Setting Up a Grievance Process	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline	
p-value 1-tail	0.0550	0.0239	0.2121	0.5000	0.0044	0.2506	0.0548	0.1528	0.0645	0.5000	
Effect Size	0.2774	-0.7965	0.2268	0.0000	-0.7326	-0.1184	0.2529	0.2667	0.2628	0.0000	

Class 10: Fall 2017 Petroleum Engineering Senior Seminar (Mines)										
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.										
	Shareholders	Employees	Communities	Society	Suppliers and subcontractors	Customers	Government	Activists	Future generations	
p (t-test)	0.5405	0.1028	0.0601	0.3336	0.2356	0.5405	0.0898	0.1463	0.0109	
Effect size	0.0967	0.2734	0.5198	0.1457	0.1830	0.0902	-0.2392	0.2082	0.4754	
Q5: How would you rate the importance of companies engaging in each of the following as part of their CSR efforts?										
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline	
p-value 1-tail	0.4448	0.0390	0.0509	0.4469	0.0658	0.2750	0.0224	0.1651	0.3770	
Effect Size	-0.0184	-0.3294	0.2400	0.0170	-0.1838	0.0863	-0.2714	0.1243	0.0461	

Class 10: Mine Reclamation and Environmental Management (Va Tech)											
Q9: In your view, to whom do corporations have the MOST responsibilities? Rank in order of importance.											
	Shareholders	Employees	Communities	Society	Suppliers	Contractors	Customers	Government	Civil Society Orgs	Activists	Future Generations
T test	0.264	0.206	0.202	0.594	0.280	0.016	0.064	0.955	0.306	0.471	0.186
Wilcoxon	0.067	0.185	0.179	0.650	0.414	0.015	0.034	0.942	0.185	0.272	0.139
Effect size	-0.249	-0.267	-0.271	-0.116	0.259	0.624	0.371	-0.012	0.214	0.139	-0.288
Q5: How would you rate the importance of companies engaging in each of the following as part of their CSR efforts?											
	Community Training	Redesigning Industrial Process	Giving Scholarships	Reporting Expenditures	Setting Up a Grievance Process	Employee Charity	Building Water Treatment Plant	Reporting Unsafe Practices	Prioritizing Local Hires	Rerouting pipeline	
p-value 1-tail	0.0429	0.1284	0.0073	0.0081	0.1620	0.1999	0.2372	0.2854	0.0336	0.4111	
Effect Size	0.3810	-0.2860	-0.5009	0.5221	-0.2599	-0.2207	-0.1492	-0.1519	0.3921	0.0221	

References

[1] D. Johnson, "Rethinking the Social Responsibilities of Engineers as a Form of Accountability," in *Philosophy and Engineering: Exploring Boundaries, Expanding Connections*, D. P. Michelfelder, B. Newberry, and Q. Zhu, Eds. Switzerland: Springer, 2017, pp. 85–98.

[2] C. Mitcham, "Ethics is Not Enough: From Professionalism to the Political Philosophy of Engineering," *Leadersh. Pers. Manag. Concepts Methodol. Tools Appl.*, pp. 1350–1382, 2016.

[3] J. A. Leydens and J. C. Lucena, *Engineering Justice: Transforming Engineering Education and Practice*. Wiley-IEEE Press, 2017.

[4] G. Auld, S. Bernstein, and B. Cashore, "The New Corporate Social Responsibility," *Annu. Rev. Environ. Resour.*, vol. 33, pp. 413–435, 2008.

[5] R. E. Freeman, *Strategic Management*. Cambridge New York Melbourne Madrid Cape Town Singapore: Cambridge University Press, 2010.

[6] N. M. Smith, J. M. Smith, Q. Zhu, and C. Mitcham, "Deepening Engineering Ethics by Exploring the Corporate Dimensions of Social Responsibility," presented at the Association for Applied and Professional Ethics, Dallas, Texas, 207AD.

[7] M. Welker, *Enacting the Corporation: An American Mining Firm in Post-Authoritarian Indonesia*, 1 edition. Berkeley: University of California Press, 2014.
[8] D. Rajak, *In Good Company: An Anatomy of Corporate Social Responsibility*. Palo Alto: Stanford University Press, 2011.
[9] F. Li, *Unearthing Conflict: Corporate Mining, Activism, and Expertise in Peru*. Durham ; London: Duke University Press Books, 2015.
[10] J. S. Rolston, "Turning Protesters into Monitors: Appraising Critical Collaboration in the Mining Industry," *Soc. Nat. Resour.*, vol. 28, no. 2, pp. 165–179, Feb. 2015.
[11] M. Welker, "'Corporate Security Begins in the Community': Mining, the Corporate Social Responsibility Industry, and Environmental Advocacy in Indonesia," *Cult. Anthropol.*, vol. 24, no. 1, pp. 142–179, 2009.
[12] R. Foster, *Coca-Globalization*. New York: Palgrave, 2008.
[13] J. M. Smith, C. J. McClelland, and N. M. Smith, "Engineering Students' Views of Corporate Social Responsibility: A Case Study From Petroleum Engineering," *Sci. Eng. Ethics*, vol. 23, no. 6, pp. 1775–1790, 2017.
[14] N. M. Smith, J. M. Smith, L. A. Battalora, and B. A. Teschner, "Industry–University Partnerships: Engineering Education and Corporate Social Responsibility," *J. Prof. Issues Eng. Educ. Pract.*, vol. 144, no. 3, p. 04018002, Jul. 2018.
[15] J. M. Smith *et al.*, "Student Learning About Engineering and Corporate Social Responsibility: A Comparison Across Engineering and Liberal Arts Courses," presented at the 2018 ASEE Annual Conference & Exposition, 2018.
[16] G. M. Sullivan and R. Feinn, "Using Effect Size—or Why the P Value Is Not Enough," *J. Grad. Med. Educ.*, vol. 4, no. 3, pp. 279–282, Sep. 2012.
[17] J. Y. Tsai, D. A. Kotys-Schwartz, and D. Knight, "Introducing Actor–Network Theory via the Engineering Sophomore Year," presented at the 2015 ASEE Annual Conference & Exposition, 2015, pp. 26.1021.1-26.1021.18.
[18] J. Moon, *Corporate Social Responsibility: A Very Short Introduction*, 1 edition. Oxford: Oxford University Press, 2015.
[19] R. Davis and D. M. Franks, *Costs of Company-Community Conflict in the Extractive Sector*. Corporate Social Responsibility Initiative Report (John F. Kennedy School of Government, Harvard University, Cambridge, MA), 2014.
[20] D. Riley, "Engineering and Social Justice," *Synth. Lect. Eng. Technol. Soc.*, vol. 3, no. 1, pp. 1–152, Jan. 2008.
[21] G. Rulifson and A. R. Bielefeldt, "Evolution of Students' Varied Conceptualizations About Socially Responsible Engineering: A Four Year Longitudinal Study," *Sci. Eng. Ethics*, Mar. 2018.