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Integration of Diversity, Equity, and Inclusion Topics into a First-Year Introduction to Civil Engineering Course

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Abstract
This paper presents an example of how diversity, equity, and inclusion (DEI) topics have been integrated into an Introduction to Civil Engineering course for first-year (FY) students. DEI issues were integrated into the topics of ethics and sustainability, as well as being a stand-alone topic in 2020-2022. Each of these three topics had an associated individual homework assignment supported by readings and/or online videos. The specific prompts and readings/ videos changed over time. The DEI teaching practices aligned with self-determination theory (e.g., autonomy). Evidence of the effectiveness of the DEI integration approaches is provided via content analysis of a homework assignment and the final reflective essay. In addition, there was no evidence of student resistance to DEI topics in the course. The results provide specific examples that can support civil engineering programs in fulfilling the new proposed ABET civil engineering program criterion related to DEI.

Keywords: ethics, sustainability, DEI, diversity, equity, inclusion, justice, student resistance, self determination theory, autonomy

Introduction

The paper begins by presenting the motivation for incorporating DEI issues into civil engineering courses. This includes the documented benefits of DEI, the lack of demographic diversity in engineering, and the formal support for DEI education from the American Society of Civil Engineers and ABET. This is followed by a summary of the overlaps of DEI issues with engineering ethics and sustainability. The background information concludes with examples of the integration of DEI issues into higher education and student resistance. This background provides the motivation for the present study, which explored DEI integration into a course designed to introduce first-year students to civil engineering. The details of the curricular intervention are described, followed by an examination of evidence indicating the effectiveness of the DEI integration, and then determining if there was student resistance (or the lack of resistance) to DEI instruction.

Background

Engineers are increasingly recognizing the importance of diversity, equity, and inclusion (DEI) in our work. This includes the benefits of inclusive and diverse teams in developing creative solutions to society's most difficult problems, as well as the social justice issues of providing equitable opportunities for all people regardless of their demographic traits [1], [2], [3].

Engineers are still not very diverse in the U.S. The demographics of students graduating with B.S. degrees in engineering has some encouraging trends with respect to the percentage of degrees awarded to females, which reached 24% in 2021 up from 18.4% in 2011 [4], [5]. The percentage of BS degrees awarded to women vary significantly across different disciplines, being the highest in environmental at 57.8%, above average in civil at 28.1%, and the lowest in

computer at 15.4% [4]. Underrepresented minorities (URM) earned 16.5% of the BS degrees in engineering in 2021 (up from 13.3% in 2011 [5]), ranging from a high of 21.6% in civil engineering to a low of 10.4% in engineering science and engineering physics [4]. The engineering workforce is less diverse. The U.S. Bureau of Labor Statistics data from 2021 indicates that among employed individuals, civil engineers are 17.4% women, 78.8% white, 12.8% Asian, 9.3% Hispanic, and 6.6% Black [6]. These demographics are very similar to the overall category of "Architecture and Engineering" occupations.

The American Society of Civil Engineers (ASCE) has had a policy statement related to DEI since 1993. It was significantly revised in 2021 [7], indicating a commitment to:

> "foster( ) a fully inclusive culture that celebrates individual uniqueness, engenders a sense of belonging, and promotes equitable opportunity for all people to participate as members and stakeholders of the civil engineering community regardless of identity" and "inclusive engineering problem solving that recognizes, values, and addresses the unique needs of diverse demographic, social, economic, and cultural groups…."

The ABET Board of Directors released a statement of commitment to the principles of diversity and inclusion in 2017 [8], which was reaffirmed in 2022 [9]. The Engineering Accreditation Commission (EAC) requirements include DEI issues in the definition of team and outcome 5 under the student outcomes of Criterion 3 (see Appendix) [10]. In 2021 the Big 10+ university's Deans of Engineering wrote a letter advocating for the explicit inclusion of DEI in the general criteria [11]. This more substantial inclusion of DEI into the accreditation requirements is still evolving. The 2022-2023 criteria document [12] included proposed changes to: (1) add inclusion, diversity, and equity definitions, (2) add an element to Criterion 5 - Curriculum, and (3) new requirements under Criterion 6 - Faculty. These changes are reproduced verbatim in the Appendix. These changes were released on October 30, 2021, and opened to public comment. Not all comments have been positive, e.g. [13]; based on public comments there may be changes before the proposed DEI requirements are finalized. In addition, a recent proposal to modify the civil engineering program criteria includes DEI elements [14], stating: "the curriculum must include application of principles of … diversity, equity, and inclusion to civil engineering problems." Overall, it appears that in the future engineering degree programs accredited under ABET must include some explicit instruction on DEI issues.

There are number of intersections among engineering ethics and DEI [15]. The American Society of Civil Engineers (ASCE) strongly integrated DEI concerns into its Code of Ethics in 2017 [16], with the addition of Fundamental Canon 8 (Appendix). These DEI issues were retained in the current 2020 version of the Code of Ethics [17], integrated under practices with respect to Society:

> **"f.** treat all persons with respect, dignity, and fairness, and reject all forms of discrimination and harassment;
> **g.** acknowledge the diverse historical, social, and cultural needs of the community, and incorporate these considerations in their work;"

and Peers:

> **"d.** promote and exhibit inclusive, equitable, and ethical behavior in all engagements with colleagues;
> **g.** supervise equitably and respectfully."

Given the explicit inclusion of DEI issues in the ASCE Code of Ethics, educators who stay up-to-date in teaching civil engineering students about ethics would include these DEI issues. Unfortunately, many other professional engineering ethics codes are less clear about DEI issues. The NSPE code [18], for example, does not directly refer to DEI issues until Section III Professional Obligations (e.g., 1.f. "treat all persons with dignity, respect, fairness and without discrimination").

Sustainability also intrinsically embeds DEI issues, largely within the social 'pillar' [19], [20]; e.g., "Global sustainability offers the only viable path to human safety, equity, health, and progress" [21, p. 6]. There are strong synergies between ideas of generational equity and sustainable development, for example [22], [23]. Within civil engineering, the infrastructure sustainability rating system Envision [24] is commonly used. Envision has been integrated into engineering education as a method to educate students about sustainability [25], [26], [27]. DEI issues are included within the Envision credits including the following examples:

- QL1.2 Enhance Public Health and Safety [24, p. 32]
  - "Measures taken to increase safety and provide health benefits on the project site, surrounding sites, and the broader community in a just and equitable manner
  - E) Health and safety benefits and/or negative impacts are equitably distributed within affected communities… the project does not disproportionately burden one community over another (e.g., social / environmental justice)"
- QL3.1 Advance Equity and Social Justice [24, p. 48]
  - "Degree to which equity and social justice are included in stakeholder engagement, project team commitments, and decision making
    A) When projects impact, or potentially impact, indigenous communities, specific attention is given to developing a relationship of respect and mutual understanding that supports the autonomy, authority, and rights of these communities.
    F) …qualified professionals identify unconscious biases and barriers to inclusion"
- LD3.2 Develop Local Skills and Capabilities [24, p. 82]
  - "Restorative: (D) Training and skill development programs specifically target economically depressed, underemployed, or disadvantaged communities."

Student resistance to DEI topics and instructors teaching DEI topics, including cultural competency and social justice, have been documented; e.g., [28], [29], [30]. These same studies also found that many students appreciated and were receptive to these topics. Different types of student resistance have been characterized, and it has been found that the gender and race/ethnicity of the instructor impacted the forms of resistance [28], [31]. Examples of student resistance include silence during classroom discussion (i.e., *silent resistance*) and skipping class on days when DEI topics are discussed (i.e., *absent resistance*) [28], [30]. Marano [30] also documented "heated debates and teary eyed discussion in the classroom" (i.e., *vocal resistance*) and students writing short disengaged journal entries. Students may also indicate resistance via course evaluations, including attacking instructors' instructional styles, content knowledge, and character [28]. In the study by Micheal et al. [29] resistance primarily resulted when students felt that the content attacked dominant cultures, the students felt personally attacked, or students questioned the relevance of the topic. Marano [30] attributed student resistance to boredom, a topic that contradicts student's personal beliefs, and low self-esteem regarding their academic

abilities. Recommendations to counter student resistance included highlighting the relevance of the material to future practice [29].

Lee et al. [32] studied student perceptions about learning DEI topics in engineering courses via interviews with 41 students. Interest levels in learning about DEI varied but most were positive, with most participants viewing diversity related competencies as useful. However, some students also discussed drawbacks associated with learning about DEI in engineering, largely due to concerns about trade-offs of time perhaps better spent on other topics. It is also relevant to consider that some students felt that diversity could not be taught but rather had to be experienced; e.g., "no one's going to listen to you if you lecture them on diversity…." [32, p. 155]. It is worth noting that the students who participated in the interviews may not be fully representative; leverage salience theory would posit that a student with more positive views about DEI would be more likely to participate in the interviews [33]. Thus, the study results should not be expected to represent the full extent of student resistance to learning about DEI in engineering that might be encountered.

Many examples of integrating DEI issues (including social justice) into engineering courses have been published (e.g., [34] – [39]), with varying levels of success and some documenting student resistance [36], [38], [39]. In the Murphy et al. study [39], for example, the completion rates for the DEI assignments in the course were high but lower than for technical assignments. In a survey, 8.3% of the students indicated that the DEI assignments were not suitable for the course (representing explicit resistance); 62.4% indicated the DEI assignments were suitable and suggested some changes. On end-of-semester anonymous student evaluations of the course and teaching, a few negative responses regarding the DEI assignments were written in (examples of vocal resistance), while many other comments about the DEI assignments were positive.

Research Questions

The goals of this Scholarship of Teaching and Learning study are to document the integration of DEI elements into a first-year civil engineering course. The experience is explored to determine which aspects seemed effective and if there is evidence of student resistance. Three types of evidence of students' silent resistance to these topics is examined: (1) electing to skip class (non-attendance); (2) not completing the assignments; and (3) less engagement on the DEI assignments as measured by the word length of the responses. In addition, student survey results are examined, including responses on a pre / post survey that measure their attitudes, and fully anonymous responses on the student evaluations of teaching completed at the end of the term; these might reveal vocal resistance. The data are also explored for potential differences among demographic groups (i.e., female vs. male students; URM vs. non-URM).

Course Overview

The civil engineering BS degree at the University of Colorado Boulder (CU) requires a 1-credit *Introduction to Civil Engineering* course, designed for first-year students in their first semester. Engineering students not declared as civil engineering majors are also able to enroll in the course. The course goals primarily revolve around helping students understand the civil engineering discipline. Among this broad aim are also specific learning objectives to describe the

ethical behavior expected in civil engineering, and define sustainability and describe its importance to civil engineering. In fall 2020 during the COVID pandemic and following peaceful protests and riots related to racism in the wake of the George Floyd killing, CU determined that all incoming students would take a CU101 course that met learning objectives related to: (1) COVID-19 education and community safety expectations; (2) health & wellness, and (3) inclusion, diversity, equity, social justice, and anti-racism. Within civil engineering, this 1-credit introductory course was identified as the course through which students would be educated on these topics. This paper focuses on the DEI integration in the course, which included a homework assignment and has persisted through fall 2022. Starting in 2020, the lowest two homework assignment scores (out of 12 total homeworks) were dropped from students' grade. Frequently, students opted not to complete two assignments, likely due to topic interest or feeling sick or overwhelmed at that point in the semester. The course grade also included attendance, a team project, and a final written reflection.

Local Context

In 2017, the College of Engineering strategic vision included a goal to increase the diversity of the student body, specifically "Be the first public engineering college with a 50 percent women undergraduate population while reflecting the demographics of our state's high school graduates" [40]. The College has had some success in working toward this goal (Table 1), particularly among first-year students (although the COVID pandemic seemed to somewhat derail the success of recruiting female FY students).

Table 1. CU Fall Enrollment Demographics over Time

Category	2022	2021	2020	2019	2018
% female College of Engineering	30.5	29.7	29.2	29.4	28.0
% female FY College of Engineering	**38.6**	**31.2**	**33.1**	**45.3**	**43.0**
% female Civil Engineering	36.6	35.9	36.9	33.2	33.2
% female FY Civil Engineering	**24.2**	**34.5**	**38.3**	**36.1**	**32.5**
% URM College of Engineering	14.6	14.8	15.0	14.7	13.2
% URM FY College of Engineering	**23.5**	**22.2**	**19.1**	**26.8**	**18.7**
% URM Civil Engineering	13.8	14.4	14.7	17.1	14.9
% URM FY Civil Engineering	**27.2**	**17.2**	**19.2**	**16.7**	**22.5**

Methods

The DEI assignments submitted by the students were coded for themes by the author. After reading the assignments it appeared that many included ideas that mapped to the ethical requirements in the ASCE Code of Ethics [17]. Thus, six *a priori* codes were developed and then used for deductive coding. An optional extra credit survey was given at the start and end of the semester. The survey was not designed to evaluate student attitudes around DEI issues, but contained a variety of items on the related topics of ethics and sustainability. In 2020 the survey was administered online due to the course being taught remotely during COVID. In 2021 and 2022 a hard copy of the pre-survey was handed out on the first day of class. The post survey was available online and also handed out on the last day of class. Response rates were much higher on the pre-survey (71-88%) than the post-survey (25-63%). Results in this paper represent only the paired responses where students completed both the pre and post surveys.

DEI Course Integration Details

Ethics

The ethics homework assignment for the course in 2019 to 2022 are shown in Figure 1. In 2019 portions of the American Society for Engineering Education (ASEE) Community Panel [42] were shown in-class. During the panel Lena Young-Green discusses how her community in Tampa, Florida, was impacted when the interstate highway was routed through it. In 2020 to 2022 a discussion of this situation was integrated into the ethics homework assignment. The assigned book chapter from 2011 [41] includes an older version of the ASCE Code of Ethics which pre-dates the addition of DEI. Thus it was important to refer the students to the contemporary version of the ASCE Code of Ethics.

Figure 1. Directions for the ethics-related homework assignment over time

2019	2020	2021 and 2022
Read the ethics chapter in Penn and Parker [41]. Select ONE of the eight canons from the ASCE Code of Ethics [16] that you find interesting. (Note: Chapter is old and missing 8th canon.) Write a short reflection on this canon: • Which canon did you select? Summarize it in your own words. • Describe a situation related to this canon that might confront a civil engineer – it may be one that you read about in the chapter, that you have heard about in the news, or could imagine • Why is it important that engineers conform with the ethical canon that you selected? *Response should be 300-500 words.*	Read the ethics chapter in Penn and Parker [41], the ASCE Code of Ethics [16] and watch portions of the ASEE Community Panel video [42]. Write a short reflection on the relationship between the ASCE Code of Ethics and what the speaker was discussing: 1. Discuss two or three canons (including specific sub-parts) that you believe relate to the situation described with the interstate highway system and local community in Tampa Florida. Summarize each canon and how it relates. In what ways does the situation appear ethical or unethical in relation to the codes. 2. It what ways does the code of ethics appear to fall short of considering the benefits/harms to the local community of the speaker? What did you find most compelling from Lean Young-Green? 3. How does the skill of listening relate to ethical engineering? *Response should be 250-500 words.*	Read the ethics chapter in Penn and Parker [41], the ASCE Code of Ethics [17] and watch portions of the ASEE Community Panel video [42]. • Discuss two or three sub-parts of the Code that you believe relate to the situation described with the interstate highway and local community in Tampa FL. Be sure to clearly identify the Code sub-part (example: Stakeholder 1. Society, part i). Summarize each canon and how it relates. In what ways does the situation appear ethical or unethical? • What did you find most compelling from Lena Young-Green? • Are there ways that the code of ethics appear to fall short of considering the benefits/harms to the local community of the speaker? Might the situation that occurred have been avoided if civil engineers were complying with the new 2020 Code of Ethics as compared to older ASCE Code of Ethics (in the book chapter) ? • How does the skill of listening relate to ethical engineering? *Response should be 250-500 words.*

On the video of the ASEE panel [42] community members shared stories that link to both ethics and environmental justice concerns, which tend to predominate in marginalized and underserved communities with larger than typical representation of low income and/or racial/ethnic minorities (Table 2). Some students watched segments of the video beyond what was assigned and discussed those other situations in their assignment.

Table 2. Community situations represented by citizens on the ASEE panel [42] (including additional references for more information)

Community	Situation	Speaker, race/ethnicity
Milwaukee, Wisconsin	Unsafe levels of lead in drinking water, "overwhelmingly, the people living in those houses tend to be racial and ethnic minorities" [43]	Robert Miranda, Hispanic
Flint, Michigan	Unsafe levels of lead in drinking water, systemic racism played a role [44]	E. Yvonne Lewis, Black
Isle de Jean Charles, Louisiana	Resettlement of a Native American community as a result of loss of their land due to coastal erosion and sea level rise; confounded by indigenous rights issues [45]	Albert P. Naquin, Native American
Buffalo, New York	Hazardous air pollutants from Tonawanda Coke, primarily impacting low income and Black residents [46]	Sydney Brown, Black
Tampa, Florida	Interstate highway located in Black neighborhoods displacing families and businesses [47]	Lena Young-Green, Black

Sustainable Engineering

The sustainable engineering assignment over time is summarized in Figure 2. The readings have changed. In addition, the story of the Isle de Jean Charles community from the ASEE Panel video was incorporated into the sustainability homework assignment in 2020-2022; this portion of the video was shown in-class during 2019.

Figure 2. Sustainability assignment requirements over time

2019	2020 and 2021	2022
Select 1 of the 2 reading options: A) Resilience and Sustainability of Civil Infrastructure: Toward a Unified Approach, pages 1-8 [48]. [Select if you are familiar with the general idea of sustainability] OR B) Chapter 1 and 3 of *Engineering for Sustainable Development: Guiding Principles* [49] 1. Define sustainable engineering, in your own words 2. Identify the reading you selected and WHY (1 sentence) 3. *Reading A*: Compare / contrast resiliency with sustainability in the context of civil engineering infrastructure OR *Reading B*: From among the 12 principles of engineering for sustainable development, select three that you find the most compelling. For each of the three discuss why you picked it and how it is relevant in a civil engineering context. *Total response should be 300 to 500 words.*	Read Chapter 1 and 3 of *Engineering for Sustainable Development: Guiding Principles* [49]. <u>And</u> Listen to ASEE community panelist Chief Albert P. Naquin from Isle de Jean Charles, minutes 6:29-7:29, 24:30-31:45 [42] 1. Define sustainable engineering, in your own words 2. From among the 12 principles of engineering for sustainable development in the RAE report, select two or three that you find the most related to the Isle de Jean Charles community and its civil engineering issues. For each of the two or three discuss how it is relevant. 3. What one element from Chief Albert's presentation did you personally find the most impactful. *Response should be 250 to 500 words.*	Read introductory information on the ENVISION sustainability rating system for infrastructure [24], pages 11-19. Listen to ASEE community panelist Chief Albert P. Naquin from Isle de Jean Charles, minutes 6:29-7:29, 24:30-31:45 [42] Write one or more sentences that discusses each of the following**:** 1. Define sustainable engineering, in your own words 2. From among the Envision credit list (table on pg. 23), select three credits, each from a different category, that you find the most related to the Isle de Jean Charles community and its civil engineering issues. For each credit discuss how it is relevant. *The 5 categories are Quality of Life, Leadership, Resource Allocation, Natural World, Climate & Resilience.* 3. What one element from Chief Albert's presentation did you personally find the most impactful. *Response should be 250 to 500 words.*

DEI

The DEI homework assignment was positioned between the ethics and sustainability topics in 2020 and 2021, and was moved after both ethics and sustainability in 2022. Grounding DEI in the ethical principles of engineers and endorsed by authoritative groups was intentional to lend a weight of legitimacy to the topic. Students were instructed to select from among a curated list of 6 to 8 readings, podcasts, and videos on DEI topics (Table 3). These were largely sourced from engineering professional societies, such as the ASCE, to help ensure credibility. Giving students a choice was hoped to increase their interest and motivation, in alignment with the autonomy element of self determination theory [50], [51]. The specific instructions for the write-up changed between 2020/2021 and 2022; see Figure 3. For example, the DEI definitions provided by students in 2021 seemed generally *pro forma* rather than insightful, and so that portion of the assignment was removed in 2022. The quality of the discussions in the 2021 assignments were also not as rich as the 2020 assignments. Therefore some resources were changed and students were required to use at least two sources in 2022.

Table 3. DEI resources and number of students who selected the resource in each year

Listed order 2020.2021.2022. Resource Title	**2020**	**2021**	**2022**
1.1.3. NSPE, Why Should I care about diversity in engineering? 2020 [52]	36	21	31
2.x.x. ASCE Panel Engineering a Culture of Inclusion in the Face of Injustice, Q. Alexander, Y.E. Pearson, B. Shields [53]	15	-	-
3.5.x. Medici Effect: Driving Innovation thru Diversity, Frans Johansson, 33-min [54]	1	2	-
4.x.x. ASCE Engineering a Culture of Inclusion [55]	4	-	-
5.6.8. NPR, 'Whistling Vivaldi' and Beating Stereotypes, April 12, 2010, 30-min [56]	8	3	7
6.7.x. Jacobs. 2020. Creating Social Value thru Infrastructure (64 pp) [57]	0	3	-
X.2.6. ASCE Podcast: Engineering a Culture of Inclusion Part 1: Time for Change, Yvette Pearson; 16 min [58]	-	1	3
X.3.7. ASCE Podcast: Engineering a Culture of Inclusion Part 3: Making a Difference, Sydney May, 15 min [59]	-	1	4
X.4.2. ASCE Podcast: Engineering a Culture of Inclusion Part 4: Unconscious Bias: Kim Parker Brown, 19 min [60]	-	3	5
X.x.1. ASCE Examining Social Equity in Infrastructure, Prof. M. Trotz, 25 min [61]	-	-	11
x.x.4. How Diverse Teams Drive Innovation (Part 1), Miguel Alemany, 22 min [62]	-	-	17
x.x.5. Engineering more equitable communities, Autodesk, 12 min video [63]	-	-	26

X; - = not an option provided to students to select

The order that the DEI resources were listed in the Canvas folder is shown in Table 3. The NSPE reading was the most popular every year, even in 2022 when it was not listed first (and therefore less likely to be selected due to primacy bias). The title of the NSPE article was perhaps the most compelling to the largest number of students in the class. The second most popular resource in 2022 was the 12-min video from Autodesk; it was the shortest among the video options. It is unclear if some students watched, listened to, or read more resources but then chose to write about a smaller number in the assignment.

Figure 3. DEI assignment instructions

2020/2021	2022
Read or watch one or more of the readings or videos in the Canvas DEI folder: 1. Identify the items that you read / watched. Comment on what in particular stood out to you in the article or video. 2. Define at least 1 of the following: diversity, equity, inclusion, and/or racism. 3. Why are these DEIR issues of concern in civil engineering 4. In what ways can you contribute to equity and justice issues? *Your response should be 250-500 words.*	1. Read, listen, or watch one of the readings, podcasts, or videos in the Canvas 'Diversity, Equity, Inclusion' module folder. **Identify** the item that you read / watched. Comment on at least two elements that stood out to you. 2. Read, listen, or watch a second item from the Canvas 'Diversity, Equity, Inclusion' module folder. Identify the item that you read / watched. Comment on at least two elements that stood out to you. 3. Discuss why DEIR issues are of concern in civil engineering. 4. Discuss the ways that DEIR issues might affect you personally in your future career and work. *Your response should be 250-500 words.*

The resource use by different demographic groups in the course in 2022 is summarized in Table 4; both similarities and differences are evident. The most popular resource among both male and female students was the NSPE reading. However, among URM students the 'engineering more equitable communities' video was the most popular. 'Whistling Vivaldi' was significantly more popular among female students in the course compared to males. The results provide insights into why allowing students to select among an array of options to match their interests might be an effective strategy.

Table 4. Percentage of students who selected different DEI resources in 2022

List order. Resource Title	Male	Female	URM	WhM
N students	*36*	*18*	*17*	*22*
1. ASCE, Examining Social Equity in Infrastructure, Maya Trotz; 25 min [61]	24	17	18	27
2. ASCE Podcast: Unconscious Bias: Kim Parker Brown, 19 min [60]	11	6	12	14
3. NSPE, Why Should I care about diversity in engineering? [52]	**58**	**56**	47	**59**
4. How Diverse Teams Drive Innovation (Part 1), M. Alemany, 22 min [62]	36	22	29	41
5. Engineering more equitable communities, Autodesk, 12 min [63]	47	50	**65**	36
6. ASCE Podcast: Time for Change, Yvette Pearson; 16 min [58]	6	6	6	9
7. ASCE Podcast: Making a Difference, Sydney May, 15 min [59]	6	11	12	5
8. NPR, 'Whistling Vivaldi' and Beating Stereotypes, 30 min [56]	6	28	12	0

WhM = white male students

Results: Understandings of DEI

DEI Assignment Content

The content of the students' DEI assignment in 2022 was analyzed through a lens of the ethical obligations to stakeholders, modeled after the ASCE Code of Ethics [17]. Results are summarized in Table 5, with different demographic groups shown. Individual student assignments included 1 to 5 of the six themes analyzed. Under the first theme of societal impact, the Audodesk video seemed particularly impactful at illustrating redlining and other practices that resulted in infrastructure being biased against some groups (a concept that many students indicated they had been unaware of previously). A few of the themes (e.g., Profession d and Peers d) had some opposing statements based on whether the student was in the 'traditional majority' or 'historically marginalized / underrepresented'. The themes were clearly impacted by which resource the student used for the assignment. Beyond the themes in Table 5, some essays

included other ideas (e.g., stereotype threat, pro bono work for underserved communities, etc.).

Table 5. Prevalence of themes in the 2022 DEI student homework assignments, grounded in the ASCE Code of Ethics [17]

Theme	% All (n=54)	% White Male (n=22)	% female (n=18)	% URM (n=17)
Society (g): incorporate community diversity considerations in their work	76	64	61	94
Society (f): treat all people with respect and reject discrimination	7	0	0	12
Profession (d) reject unfair competition, such as being hired (or not hired) based on gender or race/ethnicity	37	36	39	47
Profession (e) serve as a role model for future engineers, helping to increase diversity in the profession	9	5	6	12
Clients and employers: benefits via diverse teams to profit and/or quality of solutions	59	50	50	59
Peers (d) promote inclusive and equitable behavior with colleagues (ideas of being inclusive *or* acknowledging they might be discriminated against)	44	36	44	53

Some students were surprised to learn about the low demographic diversity of engineers. A white male stated, “Another thing that stood out to me was how only 20% of engineering graduates are female, which is shockingly low. This was surprising to me after having met many female engineering students in my time here at CU.” Example comments from a Hispanic female and Hispanic male, respectively, included: “…it stated that ‘20% of engineering graduates are female’. Now that really shocked me because I know that going into engineering there wasn't going to be many women but I didn't think it was that low” and “I knew from personal experiences that Hispanics made a really small amount of the STEM degrees but I didn't know it was that small.” Given these students’ concerns, during lecture newer data and numbers specific to civil engineering (and CU) were presented. It is recommended that instructors should be prepared to discuss demographics and positive trends (available annually from the American Society for Engineering Education, such as [4], [5]).

There was concern evidenced by a number of students about being hired or not hired on the basis of their race/ethnicity and/or gender. A male student wrote, “It might affect me in the future because I'm a person of color which means that I could be denied a job in the future because of my race. This is scary because I might be turned down from my dream job….” A Hispanic female student in the course stated: “It makes me worry that the person hiring me will only see me as the color of my skin and nothing else.” Some also discussed potential benefits; e.g., “as companies want to become more diverse, being a woman might be a positive for me.” There was also concern about the treatment they might experience. A student wrote, “I am a male with Mexican roots, people might discriminate against me because of my ethnic background.” A female student stated, “I like the idea of working on construction projects, but when I think about the men I may have to work with I rethink it as a career path. That maybe … I won’t be able to find ‘my people’ in the workplace, or that I will be undermined….” The responses indicate that some URM and/or female students seemed to become more concerned after the assignment about the work environments they might encounter in engineering. It is recommended to openly discuss these elements, and point the students to consider participating in co-curricular groups like the Society of Women Engineers (SWE), the Society of Hispanic Professional Engineers

(SHPE), and the National Society of Black Engineers (NSBE). These groups can help the students network with professionals and gain advice to prepare them for real-world conditions.

It is also notable that a few students did push back on what they read. As an example, a white male student in reference to the NSPE article wrote: "The second piece that stood out to me in this article was the idea of that we're discriminating against white males in the Engineering Industry. I felt like this statement was completely false and a little offensive to those who are actually discriminated against…." So faculty might want to read / watch each resource carefully and openly discuss or acknowledge controversial issues, and note that there is still a lack of consensus on a number of DEI issues.

Final Reflective Essay Assignment

The course concluded with a final reflective essay completed by each student. Students were instructed to comment on specific learning activities and readings in the course that they found personally motivating, interesting, or meaningful. The students were also asked to discuss the importance of ethics and sustainability in civil engineering. There was nothing that required students to discuss DEI issues. Simple content analysis on students' reflective essays from 2019 to 2022 was conducted starting with keyword searches followed by reading assignments that were flagged to check the context in which the words were used. The six keywords used were: divers(ity/e), equit(y/able), inclusi(on/ve), justice, racis(m/t), discriminat(e/ion). Some students included multiple DEI terms in their essay. Diversity was frequently used in non-DEI contexts (e.g., interested in the diversity of sub-disciplines of civil engineering), so those essays were not counted. Results are summarized in Table 6. A similar percentage of the students in 2021 and 2022 discussed DEI topics, as evidenced by the presence of one or more of the six keywords.

Table 6. Final essay analysis for DEI-related terms

	2019	2020	2021	2022
# (%) final essays with JEDIR terms	2 (4%)	4 (7%)	6 (20%)	12 (21%)
Terms Found [n] students	inclusiv*[2]	racis* [2], equit* [1], inclusi*[2], discriminat* [1]	raci* [1], equit*[2], inclusiv*[2], justice[2], divers* [5], discriminat* [1]	raci*[3], equit*[6], inclusiv*[2], justice[1], divers*[6], discriminat* [3]

Some example quotes from the student essays are included below:

> "I want to… be a more social, inclusive engineer" *Male white student, 2019*

> "I also learned how important it is that civil engineers never discriminate against anyone for any reason. … ensure that our world is inclusive for everyone." *Male white student, 2019*

> "I believe diversity and sustainability are the way of the future" *Male student, 2020*

> "I should be open to accept the opinions of people from various backgrounds and ethnicities, and what better way to do so than having a diverse and inclusive working environment that is equitable and lacks any form of racism" *Male international student, 2020*

> "Ethics are also important because Engineering is becoming more and more diverse. It is important that all engineers know how to treat everyone with respect, even if they are not what an engineer in the 1900s looked like. People often expect engineers to fit the profile of a straight white man, but that is rapidly changing, so we all need to learn how to interact with people who don't look like us." *Female URM student, 2021*

The simple keyword approach to identify relevant student essays had limitations. A detailed analysis of all 57 student essays from 2022 identified 24 essays that discussed DEI issues, versus the 12 identified by the keyword search. The thorough read found students talking about "people of poverty and color", "poorer communities", "Black community", "wrongs that have marginalized some communities", "underprivileged communities", etc. A number of students specifically discussed the "low bridges" that were designed so buses could not access beaches, so the Autodesk video [63] seemed particularly impactful. Students also discussed the Tampa and Isle de Jean Charles communities represented by the ASEE panelists [42] and specifically discussed the marginalized attributes of these groups. A few example quotes are shared below:

> "For me, civil engineering is the subfield of engineering that has the most potential to improve society. When I think of the most prevalent social issues, I think of things like poverty, racism (which is interrelated to poverty), and climate change. Throughout this semester, I learned that civil engineering can act as a means to fight these issues." *Male student, 2022*

> "The aspect of civil engineering that I find most inspiring is the opportunity for unprecedented growth in the near future. …Additionally, if one of these massive engineering projects created in the 1970s had to run through a highly populated area, it would follow the path of least resistance through low-income minority neighborhoods displacing those without the social influence to do anything about it. With the shortcomings of past infrastructure in mind, the new infrastructure bill allows current civil engineers to design and construct more effective national infrastructure that models the values of equity and greatness that America was created to represent. This opportunity for growth and reconstruction inspires me the most to become a civil engineer." *Male URM student, 2022*

> "Another reason I am interested in engineering is because I want to play a role in combatting the gender stereotypes and stigma in STEM fields. Engineering is a heavily male dominated field, but there is a need for diverse thinking. Different perspectives need to be heard and utilized to be able to come up with the best solutions for helping masses of people." *Female student, 2022*

> "Two ethical issues that I found very compelling was the highway system that was installed in Tampa. The creation of this new highway violated ASCE's code of ethics as it completely tore apart the lower income communities that stood in the way of where the new highway was to be built. Not only did it destroy the community in the way but it also created long lasting negative health effects for those that now lived next to this "super-highway". This was really surprising for me and the fact that they have not issued substantial reparations for the damage caused is unjust. Another issue that shocked me was the Long Island interstate and the fact that Robert Moses intentionally made the bridges too short to let buses go under. This design was intentionally chosen to prevent people who couldn't afford cars and had to

take public transit from going to the beach in Long Island. …when I read about this in the class I was extremely disturbed….” *Male student, 2022*

The student reflections at the end of the semester are believed to be the best indicator of ‘impact’ of the unit, given that students were not required to discuss DEI issues (as they were on the DEI homework assignment). In addition, the essays were written 8 to 9 weeks after the DEI unit in the course, and therefore the DEI elements in their discussion are indicative of ideas that they retained. In 2022, 42% of the students discussed DEI related topics in their final essays. The real world examples of the harms that civil engineering can have seemed to stick with many students, inspiring them to consider marginalized groups and do better when they become engineers.

End-of-Semester Survey

Optional extra credit surveys were given at the beginning and end of the semester. The survey did not directly include items related to DEI, but some of the questions were related to DEI topics. Of interest is potential change in student attitudes across the semester, so paired data is shown. Note that this omits a large number of the pre-survey responses since far fewer students opted to complete the survey at the end of the term. Students rated their perception of the importance of 10 different areas of knowledge and skills for professional engineers; the 3 areas most closely related to DEI are shown in Table 7. In 2022, the average of the three items somewhat related to DEI all increased (by 0.19 to 0.42), while technical (-0.25), business (-0.22), fundamental (math & science, -0.14), and professional skills (-0.06) all decreased slightly. (Based on paired t-tests none of the pre / post differences were statistically significant; $p > 0.10$.) The 2022 results differed from the 2021 results (where ethics decreased slightly and all other items increased or stayed the same) and 2020 results (where all of the importance ratings increased on the post survey except for fundamental skills which decreased slightly). However, data is only available for 25% of the enrolled students in 2020 and 2021 so the results may not be representative, compared to a 63% response rate in 2022.

Table 7. Average responses among students who completed both the pre and post surveys (n paired responses / total enrolled students)

Survey Item	2022 (n=36/57)		2021 (n=8/32)		2020 (n=15/59)	
	pre	post	pre	post	pre	post
Rate the importance of different knowledge and skills for professional engineers (1 = very unimportant to 7 = very important)						
Cultural awareness / understanding (of your culture and those of others)	5.5	5.9	5.5	5.8	5.1	6.0
Ethics (ensuring all of your work follows professional codes of conduct)	6.1	6.4	6.6	6.4	6.2	6.9
Societal context (how your work connects to society and vice versa)	6.0	6.2	5.5	5.9	5.3	5.9
Rate the level to which you agree / disagree (1 = strongly disagree, 7 = strongly agree)						
I believe that it is important to learn about ethics as an engineering student	6.3	6.1	6.0	6.1	5.9	6.0
Rate your degree of confidence to perform the following tasks, on a scale of 0 (no confidence) to 100 (fully confident)						
Identify the social elements of an engineering project	62	78*	45	70*	63	78*
Understand the interdependency among environmental, social, and economic aspects of engineering	60	78*	55	65	67	79

** paired t-test statistically significant difference; $p < .05$*

The only statistically significant differences on the post survey among these items were in students' self rated confidence concerning an ability to identify the social aspects of engineering projects. These ratings increased every year on the post survey. Understanding the interdependency among environmental, social, and economic elements increased a statistically significant amount in 2022 (the largest gain and the largest number of paired responses).

Results: (No) Evidence of Student Resistance

Overall, there was not evidence of student resistance to the DEI topic(s). Previous studies have reported that student absences from class on the date when DEI issues are being discussed (when the topic is known to students in advance) may be evidence of silent resistance [30]. The student absences on the dates when different topics were discussed in-class (announced in advance) are shown in Table 8. Based on the student absences, there is no evidence that DEI was a particularly unpopular topic where students opted to avoid the class discussion as a form of resistance. Student absences may have been due to illness (not excused if the student failed to email the professor). Alternatively, students may have been facing deadlines in "more important" pre-requisite courses such as calculus and physics, which sometimes led them to skip class to study or complete assignments due in other classes. Note that attendance was a graded component of the course, but students would max out this category by attending 10 to 12 of the 15 class periods (varied based on the year of the course).

Table 8. Student absences from class per discussion topic

	Year:	2019	2020	2021	2022
Attendance % of course grade		*3*	*7*	*7*	*8*
N enrolled		*58*	*59*	*32*	*57*
Topic	**(week of the semester)**	**Total n Absent / n Unexcused Absences**			
DEI	(7)	-	5 / 4	5 / 4	4 / 3
Ethics	(4 to 6)	4	5 / 3	3/ 1	6 / 3
Sustainability	(6 to 8)	6	5 / 3	10 / 9	2 / 2
Design	(3 or 4)	6	3 / 2	8 / 7	3 / 0
Creativity	(7 to 9)	13	3 / 2	11 / 11	4 / 4
Wk 1-14, average^	(1 to 14)	5.6	2.5 / 2.2	5.0 / 4.2	4.6 / 3.8

^ *note: excludes the last week of the term (week 15) which had unusually high absences every year*

The number of students who failed to submit assignments on particular topics are shown in Table 9. Again, there is not an obvious 'silent resistance' of students to the DEI topic, with a similar number of students failing to submit the DEI homework as other topics in the course.

Table 9. Number of students who did not submit homework assignments on different topics

	Year:	2019	2020	2021	2022
N student enrolled		*58*	*59*	*32*	*57*
Topic	**(week of the semester)**	**Number not submitted**			
DEI	(7)	--	5	3	3
Ethics	(4 to 6)	0	5	6	2
Sustainability	(6 to 8)	1	4	5	3
Design	(3 or 4)	0	4	3	2
Creativity	(7 to 9)	3	2	2	3
All, median		2.5	4.5	4	2.5

In 2019 all assignments counted toward the course grade; in 2020-2022 students could drop the lowest 2 scores.

As another potential measure of resistance or lack of engagement in the topic, the word counts in the student responses are summarized in Table 10. There were differences in the prompts that may have contributed to differences in the length of the student homework. In 2021 the median and third quartile word count of the DEI assignment is the shortest among the 4 topics shown, perhaps indicative of less interest in the topic. The DEI homeworks in 2021 were shorter than the DEI homeworks in 2020 (2-tailed t-test, p=0.084); perhaps the resources available were less compelling. In contrast, in 2022 the first quartile and median DEI essay lengths are the longest among the 4 topics. In 2022 there were not differences among the DEI homework lengths among students from different demographic groups (average word counts: female 395, male 397, URM 396, White male 400). In aggregate, there is not solid evidence of student resistance to the DEI topic.

Table 10. Word counts in the submitted assignments: quartile 1, median, quartile 3

Topic Year:	2019	2020	2021	2022
DEI	-	314 – 352 - 404	272 – 319 - 362	333 – 400 - 465
Ethics	312 – 328 - 362	333 – 383 - 454	325 – 401 - 481	331 – 400 - 478
Sustainability	329 – 375 - 442	304 – 343 - 379	279 – 325 - 418	285 – 321 - 383
Design	331 – 366 - 436	301 – 336 - 449	263 – 357 - 430	321 – 352 - 417

End-of-semester feedback also did not indicate resistance to the DEI topics in the course. In fall 2022 the post survey included an open-ended response item that invited students to write-in their favorite and least favorite topics in the course. Among the 23 write-in responses, DEI was not explicitly identified among either the most or least favorite topics. Ethics was identified as a favorite topic by 4 students (3 female, 1 male) and least favorite topic by 14 students (4 female, 10 male; 6 URM). Two students provided context for why they listed ethics as least favorite: boring and ‘I feel like it’s self-explanatory’. Sustainability was identified as a favorite topic by 4 students (4 female; 1 URM); no students indicated that sustainability was a least favorite topic. On the fully anonymous student evaluations of teaching administered by the University, none of the write-in comments related to DEI elements in the course (2020-2022).

Limitations

This paper describes the results of an intervention in a single course, taught by the author. The author’s positionality may impact the findings. Specifically, the author’s identity as a white female. In addition, the student body characteristics may be impactful. This includes their incoming attitudes about DEI issues. The University of Colorado Boulder has a strongly pro DEI stance [64] and may be more likely to attract students who share these views compared to average college students. Further, some students may have felt that it was not appropriate to include DEI issues in the course, but given that class attendance and homework assignments were graded did not evidence their resistance through the ‘silent’ metrics examined nor vocalize their resistance during class discussions or the various surveys. Differences in the pre and post survey findings are likely to have been impacted by more than this 1-credit course. Most students were taking calculus, physics or chemistry, and a computing course. Some students were taking a first-year design course (which includes team building activities that acknowledge DEI as well as elements of Universal Design), a humanities and social science elective on engineering, ethics,

and society, participating in professional societies such as SWE and SHPE, etc. Thus the aggregate first-semester experience would be reflected in their post-survey responses.

Summary and Conclusions

This paper presented examples for integrating DEI topics into a first-year introductory civil engineering course. The course was only 1-credit and has other required learning outcomes, which necessarily limited the breadth and depth to which DEI issues could be addressed. DEI issues were embedded in both ethics and sustainability which are explicit learning outcomes for the course. The topics of ethics, sustainability, and DEI seemed to reinforce each other in positive ways. Effective resources were found, building on the ASCE Code of Ethics and Envision sustainability rating system with an ASEE community panel video, NSPE DEI article, and Autodesk video. There was not evidence of silent or direct resistance by the students to learning about DEI issues. The lack of resistance may be due in part to the flexible nature of implementation, which allowed students to exercise autonomy to select resources on the assignment and open prompts to reflect on those resources. Some female and URM students seemed to become more concerned about discrimination or adverse work conditions in engineering after the videos/readings. Instructors should be prepared to help allay those concerns, perhaps connecting students with longer term support via dedicated professional societies. Overall, the DEI integration is considered successful and provides ideas that others can consider implementing. This is particularly timely in view of the new ABET civil engineering program criteria related to DEI that are anticipated.

Appendix

ABET EAC accreditation requirements that include DEI elements [12]

"Definition: Team: A team consists of more than one person working toward a common goal and should include individuals of **diverse** backgrounds, skills, or perspectives."

Criterion 3, outcome 5: "an ability to function effectively on a team whose members together provide leadership, create a collaborative **and inclusive** environment, establish goals, plan tasks, and meet objectives."

ABET proposed changes, published in the 2022-2023 criteria [12]

(1) Definitions related to DEI [p. 49]

"Inclusion is the intentional, proactive, and continuing efforts and practices in which all members respect, support, and value others. An inclusive environment provides equitable access to opportunities and resources, empowers everyone to participate equally, and offers respect in words and actions for all.

Diversity is the range of human differences, encompassing the characteristics that make one individual or group different from another. Diversity includes, but is not limited to, the following characteristics: race, ethnicity, culture, gender identity and expression, age, national origin, religious beliefs, work sector, physical ability, sexual orientation, socioeconomic status, education, marital status, language, physical appearance, and cognitive differences.

Equity is the fair treatment, access, opportunity, and advancement for all people, achieved by intentional focus on their disparate needs, conditions, and abilities. Achieving equity requires understanding of historical and systemic patterns of disparity to address and eliminate barriers

and remove participation gaps as part of a comprehensive strategy to achieve equitable outcomes and social justice."

(2) Criterion 5 [p. 50] "(c) a professional education component that is consistent with the institution's mission and the program educational objectives and promotes diversity, equity, and inclusion awareness for career success."

(3) Criterion 6 [p. 51] "The program faculty must demonstrate awareness and abilities appropriate to providing an equitable and inclusive environment for its students, and knowledge of appropriate institutional policies on diversity, equity, and inclusion."

ASCE Code of Ethics, 2017 [16]

Fundamental Canon

1. Engineers shall, in all matters related to their profession, treat all persons fairly and encourage equitable participation without regard to gender or gender identity, race, national origin, ethnicity, religion, age, sexual orientation, disability, political affiliation, or family, marital, or economic status.

Guidelines to Practice Under the Fundamental Canons of Ethics

a. Engineers shall conduct themselves in a manner in which all persons are treated with dignity, respect, and fairness.
b. Engineers shall not engage in discrimination or harassment in connection with their professional activities.
c. Engineers shall consider the diversity of the community, and shall endeavor in good faith to include diverse perspectives, in the planning and performance of their professional services.

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