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Integrating Social and Environmental Justice into the Program Educational Objectives of [Institution]'s Civil and Environmental Engineering Department

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Abstract

After the murder of George Floyd in May 2020, an undergraduate student coalition in the Civil and Environmental Engineering (CE/ENVE) Department at California Polytechnic University San Luis Obispo proposed that the curriculum be updated to address the topics of social and environmental justice and their role in Civil and Environmental Engineering. As a result, the CE/ENVE faculty collaborated with the student leaders to integrate social and environmental justice into the CE/ENVE program educational objectives (PEOs). PEOs reflect the goals that program graduates will achieve within a few years of graduation, reflect the mission of the Department, and provide guidance for specific student learning outcomes in the classrooms. As such, they are the principle tool for guiding lasting and significant modifications to the curriculum. As part of the student-initiated PEOs revitalization, additional educational objectives were incorporated, including: resilient, sustainable, and safe design; systems-thinking; and, inclusive communications. This paper discusses the bottom-up, student-centric process used for updating the CE/ENVE PEOs, the stakeholders involved, and the students' key contributions to the process. A comparison between the revitalized PEOs and the original PEOs are presented. The focus of the work encompasses the challenges encountered during this experience and the lessons learned. Finally, this paper outlines the CE/ENVE Department's plan to integrate the new PEOs into the curriculum, including specific examples of implementation of the PEOs into selected courses and development of appropriate metrics for student outcomes. This update of the PEOs is a critical step towards re-shaping the CE/ENVE curriculum to educate the students about social justice and its strong connection to engineering design and practice. The new PEOs will result in a modern CE/ENVE curriculum that helps students develop the knowledge and skills needed to address the contemporary challenges facing the world.

1.0 Introduction

The bulk of engineering education upholds a narrow technical focus [1], [2]. Even though engineering products have consequences on society and the environment, engineering courses seldom provide students with a deep understanding of the complex societal and environmental dimensions of engineering practice [1], [3]. The insufficient education on matters of social and environmental justice can compromise the ability of engineering graduates to adequately serve the needs of their stakeholders, especially vulnerable communities. Thus, higher education institutions have an obligation to reform the engineering curricula to prepare engineers capable of advancing society through their engineering practice and outreach.

Reframing engineering as a *sociotechnical* field is one of the reforms suggested and emphasized by many engineering scholars and activists [4]. In traditional engineering education, the students are required to take social sciences and humanities courses to fulfill the requirements for their engineering degree. However, those courses are typically offered by distinct disciplinary domains that are separate from the technical engineering programs. This educational model makes the students responsible for integrating the social and technical contents on their own [5]. In most cases, students fail to make these connections between the social and technical dimensions of engineering [5]. Although design courses in some engineering programs

incorporate both social and technical elements, the social aspects are usually focused on economic and client constraints, omitting broader social and cultural dimensions [2]. Thus, teaching sociotechnical thinking will help engineering students recognize how social factors shape technical solutions (and vice versa) and empower students to bring social justice purposefully into their practice [2]. Johnson et al. specified that faculty knowledge, push back from students, and constraints in class time and content are major barriers for integration of sociotechnical thinking in engineering curriculum [6]. Systematic improvements to the engineering education system are needed to overcome such barriers and allow widespread teaching of social justice topics in engineering curricula. The United Nations (UN)'s 2030 Agenda for Sustainable Development emphasizes the need to defeat poverty and embrace social justice for all humanity [7]. This agenda further underscores the need for fostering sociotechnical thinking among future generations of engineers so that they can tackle the global societal and environmental challenges that have more severe consequences on marginalized communities.

Interest and efforts to integrate social justice into engineering curricula have increased in recent years. For example, in 2019, 117 American Society of Engineering Education (ASEE) papers included the term "social justice," compared to 49 in 2015 [8]. Although mentioned, social justice was not the primary focus of the majority of these articles. Bielefeldt interviewed 1,268 faculty who embed ethics and societal impact issues in their classes and found that 27% of the surveyed faculty integrate social justice/poverty topics into their teaching [8]. The faculty interviewed believed that teaching social justice topics was insufficient in their programs, although no broad consensus exists on what level would be sufficient.

In general, the literature demonstrate that two primary approaches have been used to integrate social justice into the engineering curricula: one approach dedicates a single course that focuses on teaching engineering ethics, social justice, workplace professionalism, among other topics; the second approach focuses on implementing broader curricular interventions to integrate social justice modules into core and elective engineering courses [3], [6], [8], [9]. Lee et al. taught social justice and social responsibility in a required first-year engineering course focusing on the nature of engineering design, engineering ethics, professional responsibilities of engineers, and the socio-economic and environmental impacts of engineering projects and products [10]. The goal of this freshman-level course is to provide the students with early exposure to these concepts, which will be later reinforced in the non-major general education elective courses. A pre- and post- class survey, involving 231 participants, was conducted to gauge the students' global, social, and environmental awareness. The survey results indicated that before taking the course, students were generally unsure if the engineering profession can help social issues, but their views changed considerably after the course as they became more aware of the need to include social justice in practice [10]. The authors also suggested that one course was insufficient to significantly change the way students think about the implications of their work on society [10]. Oulton et al. reported similar findings after discussions with faculty and students in one-on-one and town hall meetings [9]. The participants agreed that including social justice broadly across the curriculum is a better approach than concentrating such content in a single class focused on this topic. This across-curriculum approach encourages contextualization of social and environmental justice into the course content, allowing the connections between engineering and social justice to become more evident to the students [9]. Oulton et al. also conducted a survey in an environmental engineering capstone design class to probe student awareness of social and environmental justice issues before and after curricular interventions to integrate these concepts [9]. Before the curricular interventions, ~ 55% of the students in the capstone class

believed that they received social justice education in past classes. However, this student group felt that the coverage was insufficient to prepare them to handle such issues in practice.

In this paper, we describe a novel pathway for systematic and broad integration of social and environmental justice across the curriculum of the civil and environmental engineering (CE/ENVE) department at California Polytechnic University San Luis Obispo (Cal Poly SLO). The CE/ENVE Program Educational Objectives (PEOs) were updated to place social and environmental justice at the core of the educational mission of the Department. The PEOs are statements that broadly describe what students are expected to attain 3-5 years after graduating from the program [11] and are used to guide the development of the specific learning objectives of individual courses. Thus, this change in the PEOs will motivate strategic curricular interventions throughout the CE/ENVE classes to enhance the sociotechnical thinking skills of graduates of the program.

Based on analysis of the literature, it appears that most efforts to integrate social and environmental justice into engineering curricula have been faculty-driven rather than being driven by program-level goals. In the CE/ENVE Department at Cal Poly SLO, we adopted a program-level strategy to update the PEOs. The changes in the PEOs were a direct result of students' advocacy for social and environmental justice and their participation in every step of the development of the updated PEOs. The literature outlines the need for pressure from the community of scholars and educators to incorporate social justice education into engineering [1]. However, we argue that our experience shows that student drive is of equal importance to that of scholars and educators to instill sociotechnical thinking into engineering education. The main objective of this paper is to share with the community of engineering educators the unique bottom-up process through which the PEOs were updated and ratified by the CE/ENVE Department at Cal Poly SLO to integrate social and environmental justice, among other concepts, into the curriculum. This paper also provides examples of curricular interventions implemented so far to integrate social and environmental justice in the classroom in the CE/ENVE Department at Cal Poly SLO.

2.0 Motivation and Process Description for Updating the CE/ENVE PEOs

Historical inequalities (e.g., disadvantages in income, service, and participation) still persist today in society, and engineers have a role to play to change such injustices [8]. Yet, engineering programs generally did not evolve to cope with the increasing demands for education that fosters the sociotechnical thinking skills necessary to develop effective solutions to these challenges. Following the social unrest that was sparked by the killing of George Floyd in May 2020, around 50 students in the CE/ENVE Department at Cal Poly SLO sought a major change to the curriculum to make social justice at the center of their engineering education. The students formed an entity called the Curriculum Enhancement Committee (CEC) to advocate for the desired curricular changes. A representative group of the CEC students met with the CE/ENVE Department faculty to convey their concerns and dissatisfaction about the lack of classroom discussions regarding the contemporary tragic incidents and injustices that are happening in the society. At the beginning of the meeting, the faculty expressed their understanding of the students' concerns, but some pushed back on the idea that the classroom is the right venue of such conversations. A number of faculty had the mindset that the engineering class time is better utilized for teaching the technical engineering content along with the conventional non-technical skills (e.g., communication, teamwork, critical thinking, and leadership) needed for the students

to succeed in their profession. However, this meeting represented a teachable moment for the CE/ENVE faculty as they started to re-assess their mindset and position on bringing social justice issues into the classroom after listening to students' arguments. Eventually, the entire CE/ENVE department faculty became committed to integrating social and environmental justice in the curriculum as presented in this paper.

After the previously outlined meeting, the students were advised by a member of the faculty (the Department Chair) that integrating social and environmental justice into the CE/ENVE PEOs would be the ideal first step towards developing a curriculum that teaches sociotechnical thinking. Capitalizing on this advice, the students retrieved the PEOs from the CE/EVE department website and drafted a revised set of PEOs that clearly listed social and environmental justice as one of the major educational objectives of the program. In summer 2020, the students shared their edited version of the PEOs with a selected group of faculty, seeking their input. Then, the students shared a revised version of the PEOs that integrates the faculty input (Revision-1) with the CE/ENVE Department Chair, who added a task to the 2020 faculty fall retreat agenda to discuss the proposed updates of the PEOs. During a 2-hour session during the faculty retreat, a focus group consisting of faculty and student representatives discussed Revision-1 of the PEOs and proposed further changes. At the end of the session, the focus group presented their progress (Revision-2) to the entire department faculty and received full support to involve more stakeholders to continue to make necessary revisions to the PEOs. They established the goal to have updated PEOs ratified by the end of the 2020/2021 academic year. A roadmap was created (Figure 1) to update the PEOs not only to integrate social and environmental justice but also to modernize the curriculum to satisfy the needs of an evolving profession facing multiple global challenges. The CE/ENVE Department's Industry Advisory Board (IAB) was consulted about the roadmap and the intended updates of the PEOs. The IAB members were supportive of the proposed plan and highlighted its importance to the graduates of the program. They also suggested additional changes to the PEOs beyond integration of social and environmental justice.

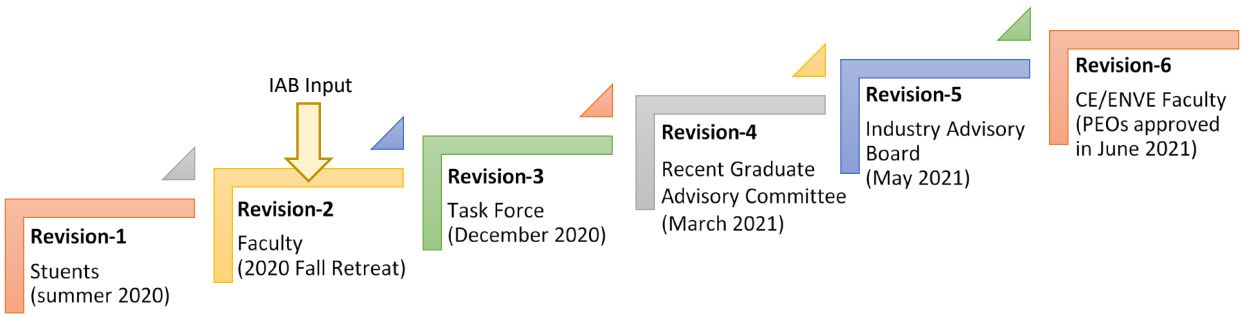

Figure 1. The roadmap for updating the CE/ENVE program educational objectives (PEOs)

A task force was formed to develop a solid draft of the new PEOs (Revision-3) according to the previously outlined recommendations by the students, faculty, and IAB members. In addition, the task force members integrated their own concepts while developing the new set of PEOs. The task force consisted of a variety of stakeholders: 7 CE/ENVE faculty (including the two Accreditation Board for Engineering and Technology (ABET) coordinators and the Department Chair); 9 CE/ENVE students; the Chair of the College of Engineering (CENG) Curriculum Committee; the Coordinator of the Multicultural Engineering Program (MEP); the Director of the Center for Teaching, Learning and Technology (CTLT) at Cal Poly SLO; the Director of the

Honors Program at Cal Poly SLO; the former Interim Associate Vice President for Diversity and Inclusion at Cal Poly SLO; and one of the IAB members. Revision-3 was completed by the task force in a 2-hour discussion session held in December 2020. Then, in March 2021, the CE/ENVE's Recent Graduate Advisory Committee (RGAC) developed Revision-4, which integrated the RGAC's input into Revision-3 created by the task force. The RGAC included 16 CE/ENVE alumni who graduated and joined the workforce within the last 3-5 years. The RGAC advises the department primarily on matters related to improving and modernizing the curriculum based on industry needs and advances. It was critical to involve the RGAC into the PEOs update process because they represent the target group of the PEOs. Revision-4 was thoroughly discussed during the IAB meeting in May 2021, resulting in Revision-5, based on the IAB's input and suggested modifications. Revision-5 was distributed to the faculty to review and provide their input ahead of the CE/ENVE Department meeting in June 2021. The faculty input prior to and during the final faculty meeting of academic year 2020/2021 resulted in Revision-6, which was unanimously approved by the CE/ENVE faculty. This step concluded the PEOs' update process that was completed within the span of one academic year, as originally desired by the CE/ENVE students and faculty.

3.0 The new PEOs and Reflections on their Update Process

The original and the updated versions of the CE/ENVE PEOs are presented in Table 1. The scope of the updated PEOs evolved and expanded from the CEC's original vision that was solely focused on integrating social and environmental justice. The additional concepts that the updated PEOs consider, based on inputs from the various stakeholders involved throughout the process, are outlined in Table 2. The updated PEOs are expected to modernize and revolutionize the CE/ENVE curriculum at Cal Poly SLO. Based on the new PEOs, curricular changes and interventions will be implemented to teach the students about creating engineering designs and products that are safe, sustainable, and resilient to the impacts induced by a changing climate. The students will also learn about and apply the concept of creating restorative solutions that not only minimize the negative impacts of a project but also restore the assets of the community and environmental resources [11]. The updated PEOs call for teaching the students systems thinking, and the need and means for pursuing professional development to adapt to constantly evolving engineering technologies and profession. Understating and integrating the needs and values of underrepresented communities was a key development in the updated PEOs. The PEOs also place an emphasis on equitable and inclusive communications with all stakeholders. The CE/ENVE Department at Cal Poly SLO offers two undergraduate degrees – B.S. in Civil Engineering and B.S. in Environmental Engineering. Originally, each degree had its own set of PEOs. However, careful analysis of the CE and ENVE PEOs reveals that they were extremely similar and thus, one set of updated PEOs was developed for the CE/ENVE department, reflecting the vision and goals of the Department as a whole.

Table 1. The original and updated CE/ENVE Program Educational Objectives (PEOs)

Original PEOs	
Civil Engineering Program	**Environmental Engineering Program**
1. Successfully perform engineering functions in Civil Engineering practice 2. Communicate and collaborate effectively with industry professionals, decision-makers and community members 3. Work in an ethical and professional manner to positively impact society and the environment in a regional, national and global context 4. Pursue life-long learning and service to the profession through continuing education opportunities, professional organizations, leadership, graduate degrees and/or other certification 5. Progress toward professional licensure	1. Apply environmental engineering principles to analyze and solve real-world engineering challenges 2. Communicate effectively, both orally and in writing, and collaborate successfully in teams 3. Address the ethical, societal, and global issues encountered in environmental engineering 4. Think independently, engage in life-long learning, and continue their development as professionals 5. Be prepared to pursue graduate study and licensure
Updated PEOs	
1. Integrate principles of sustainability, resilience, and restoration into engineering solutions 2. Communicate and collaborate with diverse stakeholders in an inclusive, effective, equitable, and professional manner 3. Implement systems thinking in engineering designs and solutions that promote public health, safety, and welfare on a local and global scale 4. Pursue life-long professional development through study, licensure, certification, leadership, and service 5. Acknowledge, understand, and incorporate the needs of diverse and vulnerable populations in outreach and engineering practice	

Table 2. The evolution of the PEOs' update goals

Stakeholder	PEOs update goals	Revision
Students	Social and environmental justice	Revision-1
Faculty	• Resiliency • Combine the CE and ENVE PEOs	Revision-2
IAB and Task Force	• Sustainability • Restoration • Totality of circumstances • Adaptation and growing	Revision-3
RGAC	Safety	Revision-4
IAB	Inclusive communications	Revision-5
Faculty	Design	Revision-6

This PEOs update process was insightful. Other departments in the College of Engineering at Cal Poly SLO are considering updating their PEOs following the lead of the CE/ENVE Department. The CEC students played a key role in making their initiative a reality. Student representatives participated in every step of the PEOs update process outlined in Figure 1. The student views were well-reflected in the new set of PEOs. This PEOs update exercise was truly a bottom-up approach for making changes to the engineering curriculum. Usually, the faculty determines

when and what changes are made to the curriculum, but in our case the changes were not only initiated by the students, but the students also participated in shaping the final outcome and provided input to stakeholder groups at each revision. The input of all the stakeholders involved in the PEO update process mattered considerably. For example, one of the PEOs in Revision-3 created by the task force was "Develop resilient, restorative, and sustainable engineering solutions that….." but the RGAC members, who represent the group that the PEOs target, reported that they do not "develop" solutions at this stage of their careers (3-5 years after graduation). As such, Revision 4 changed that PEO to "Integrate principles of resilience, restoration, and sustainability into engineering solutions that……." The task force members from the CTLT and college curriculum committee provided insights on crafting PEOs that properly align with various levels of Bloom's taxonomy of cognitive achievement. The IAB members as well as the MEP and Office of Diversity and Inclusivity representatives contributed valuable ideas stemming from their practical experience and similar efforts they pursue in the domain of diversity, inclusivity, and social justice, among others. The Department faulty with their deep knowledge of the CE/ENVE curriculum and the constraints that govern the educational process helped shape the final PEOs such that they could be attainable goals. The aforementioned examples are far from being inclusive of the contributions of all the participants in the PEOs update process. This process was eye-opening, and because of its value, the authors wrote this paper to disseminate it to engineering educators.

4.0 Integration of the New PEOs into the CE/ENVE Curriculum at Cal Poly SLO

The CE/ENVE Department is currently working on developing a program-level strategy to track and enhance the incorporation of the new PEOs across the curriculum. This section presents an overview of the thought process and challenges for incorporating the new PEOs into the curriculum and developing appropriate ABET metrics to assess student outcomes. We also provide examples of recent curricular interventions related to teaching social and environmental justice in CE/ENVE courses to illustrate our approach to addressing these challenges.

It was previously noted that PEOs are intended to reflect anticipated achievements or abilities by students within 3-5 years after they graduate, or in their early career [12]. Incorporating the PEOs themselves as learning objectives in undergraduate classes is inappropriate [12]. Therefore, one challenge with incorporating the PEOs across the CE/ENVE curriculum is understanding how to use them as guidance for undergraduate progress toward post-graduate achievement. We need to consider a trajectory of student development that culminates in these PEOs after graduation. The specific undergraduate course learning objectives (CLOs) need to establish that trajectory from introduction of concepts in early curriculum classes, to guided achievement of these PEOs in capstone or other upper division classes, to anticipated mastery of the PEOs in early career.

Bloom's Taxonomy describes a progress of cognitive development and critical thinking skills. This taxonomy has traditionally been utilized in course design to develop measurable CLOs as well as to evaluate engineering program curricula [13]. The progressive structure of Bloom's Taxonomy provides a useful model for 'backwards design" of a curriculum that establishes that desired trajectory toward post-graduation development of the skills described in the PEOs [15]. Utilizing a backwards design approach with achievement of the PEOs as a post-graduation goal, we can assess lower levels of both Bloom's taxonomies with lower-level classes and continue

assessment by developing CLOs that align with appropriately higher levels of Bloom's taxonomies as students progress through their curriculum.

The original taxonomy developed by Bloom et al addressed not just cognitive development, but affective development as well. As described by Bloom, the cognitive domain considers intellectual abilities and knowledge. By contrast, the affective domain includes more personal issues such as values and interests [13]. Table 3 presents the typical levels of Bloom's Taxonomies for both the cognitive and the affective domains, with a brief description of the cognitive or affective skill associated with each level [14].

Table 3: Bloom's Cognitive and Affective Taxonomies [14]

Level	Cognitive Domain (Description)	Affective Domain (Description)
1	Remember (remember previously learned material)	Receive (be aware of, be willing to receive, and be attentive to a particular phenomenon or behavior)
2	Comprehend (grasp the meaning of learned material)	Respond (actively participate in an activity, attend to a task, and react to motivation)
3	Apply (use learned material in new and concrete situations)	Value (attach value to a particular object, phenomenon, or behavior)
4	Analyze (break down learned material into its component parts so that its organizational structure may be understood)	Organize (sort values into priorities by contrasting different values, resolving conflicts between them, and creating a unique value system)
5	Synthesize (put learned material together to form a new whole	Characterize (follow a value system that controls behavior that is pervasive, consistent, predictable, and a defining characteristic)
6	Evaluate (judge the value of learned material for a given purpose)	

In developing a sociotechnical engineering curriculum, both the cognitive and the affective domains should be considered [14]. The cognitive domain focuses largely on the technical issues, and the affective domain provides the necessary complement for consideration of social issues. The new PEOs include issues like sustainability, ethics, and social justice, all of which require both technical and social critical thinking skills. Therefore, both cognitive and affective domain taxonomies must be utilized for development and assessment of CLOs that support the new PEOs [14]. These taxonomies may be applied over a single course or over an entire curriculum to guide skill development from low-level achievements (Remember and Comprehend in the cognitive domain, Receive and Respond in the affective domain) to higher level achievements (Synthesize and Evaluate, or Organize and Characterize) [14].

Developing appropriate metrics to assess student progress toward the new PEOs is one challenge. Two other challenges include assessing the current state of the curriculum and the current level of student cognition regarding the new concepts introduced in these PEOs. For curriculum assessment, we are initiating a 3-phase PEO mapping study. Periodic ABET review

requires mapping the PEOs against the required undergraduate classes. We have typically performed a 3-level mapping assessment (Introduce, Reinforce, Master) for our ABET reviews to document how key concepts develop over the curriculum [16], [17]. Since the new PEOs were developed subsequent to our most recent ABET review, we have not yet performed this type of mapping study for the new PEOs. Conducting this study of the new PEOs may be challenging because of the inclusion of more affective domain concepts such as social justice and sustainability in the new PEOs [14]. Understanding how to map these affective domain considerations is a newer concept for most of the faculty, so there may be a learning curve to this exercise. Therefore, for mapping the new PEOs, Phase I will simply identify if the PEO concept is included in the class. Phase II will then identify the level of achievement in each domain (cognitive and affective) measured in each undergraduate class, based on review of the class assignments and other assessments. Phase III will identify gaps and opportunities for inclusion or expansion of PEO concepts. We are also currently conducting a self-study of our Graduate Program, which will include a similar mapping effort for the upper-division technical electives and graduate classes. Together, these two mapping exercises will cover the entirety of the Department curriculum, from first-year through graduate-level classes.

Additionally, we are conducting student surveys to identify their levels of cognition regarding concepts introduced in the new PEOs [9]. Understanding student levels of critical thinking about these concepts based on the current curriculum will allow us to better develop appropriate curricular modifications to target educational goals moving forward. Surveys were conducted in both CE and ENVE first-year classes and the ENVE capstone class to determine level of cognition before and after a brief educational module on social and environmental justice (educational modules are described below) [9]. Surveys include questions targeting lower-levels of Bloom's Taxonomies, such as the ability to define fundamental terms; mid-level critical thinking skills, such as the ability to rank several proposed solutions as more or less "just"; and higher-level critical thinking skills such as considering the positions of multiple stakeholders in a hypothetical case study. These surveys are ongoing, and we anticipate that they will provide insight into where in the curriculum we should introduce and reinforce concepts, as well as where we should anticipate development of higher-level critical thinking skills about these complex topics.

Several CE/ENVE classes have recently incorporated specific materials addressing social/environmental justice in response to the same student call for curricular modifications that motivated development of the new PEOs. As stated above, our goal was to incorporate this material throughout the curriculum, so here we present specific examples from our CE and ENVE first-year classes, a 300-level (typically second or third year) class required for both CE and ENVE students, and our CE and ENVE capstone classes. These examples illustrate application of the PEO metrics discussed above.

First-year classes brought in social and environmental justice through discussion of specific case studies. In the ENVE class, students studied a community in Central California currently suffering from long-term water shortage, in contrast with California's "Human Right to Water" law [18]. In the CE class, students learned about an historical case study involving development of the Los Angeles (LA) Freeway system through an economically-disadvantaged community. The new freeway extension reduced community connectivity, decreased pedestrian safety for local residents, and increased exposure to traffic exhaust for students attending the existing elementary school adjacent to the selected freeway route [19]. Both of these modules were

developed and delivered by upper-class students from the CEC, working in consultation with the course instructors. The upper-class students earned a unit of credit, got to explore in depth a topic they had become passionate about, and had a forum to share their interest and knowledge with their first-year peers. Peer-to-peer instruction like this has been found to be beneficial for a number of reasons [20]. In this case, the upper-class students were able to develop presentations that spoke directly to first-year students at their level, which helped make the material more relatable and important to the first-year students. Further, it implicitly indicated to first-year students that these considerations are part of the engineering culture at Cal Poly SLO, so those first-years will be comfortable with this material as part of their curriculum moving forward. For both of these first-year classes, student assessments focused on low-level Bloom's Taxonomy cognitive domain goals of "remember" and "comprehend" by defining key terms in context of the case studies, and affective domain goals of "receive" and "respond" through considerations of what made these situations "just" or not.

In the 300-level Fundamentals of Environmental Engineering course, required for all CE and ENVE students, the social/environmental justice material was somewhat more integrated throughout the class, in addition to being presented in a stand-alone Module. For example, the water chemistry Module included a discussion of the redox reactions that occurred in the pipes of Flint, MI that resulted in the documented toxic lead exposure to over 80 economically-disadvantaged citizens and at least 12 deaths due to Legionnaires disease [21]. This water chemistry case study invited discussion into the roles civil and environmental engineers can play in community health and safety, and our opportunities as technical experts to elevate the voices and concerns of common citizens. A separate Module about water treatment and desalination processes included a case study and virtual tour of the Carlsbad desalination plant [22]. The follow-up discussion included consideration of the costs associated with the plant and exploration of the questions "Who benefits and who pays?" for expensive infrastructure. The stand-alone Social and Environmental Justice module included YouTube videos about 3 young adults, similar in age to the students in the class. Each video told the story of that person's experience with environmental injustice and how they dealt with it [23], [24], [25]. By sharing personal, real life and relatable experiences, students could explore the nuances of the individuals' situations without getting sidetracked by political discord that might otherwise enter into this kind of discussion. All of the social and environmental justice material in this 300-level class challenged students to demonstrate mid-level Bloom's cognitive domain skills of "apply" and "analyze" and affective domain skills of "respond" and "value."

The capstone classes in our program are designed so student teams develop preliminary designs for a real-world project, over the course of the academic year. For both the CE and ENVE capstone classes, social/environmental justice considerations were made integral elements of the design challenge itself. For the ENVE students, their required deliverables included an Environmental and Social Justice Analysis report. Guest speakers were invited to class who had prepared the Environmental Justice Analysis for the Bayview-Hunters Point Biosolids Digestor Project [26]. The professionals discussed their process and the beneficial outcomes to provide guidance to the capstone students. ENVE students are also required to complete an Envision Self Assessment for their conceptual and preliminary designs. Envision is a sustainability rating tool, similar to US Green Building Council's LEED program, but intended for infrastructure projects rather than building projects. Envision credit categories include explicit consideration of increasing community stakeholder involvement, enhancing community values and culture, and

advancing equity and social justice. Envision also provides guidance on how to improve these elements of the project design [11].

In the CE capstone class, Envision is not required, but their design report must explicitly identify community stakeholders and explain the social justice and social benefit considerations included in their design decisions. To facilitate their understanding of these expectations, students were presented with a previously-prepared professional Community Engagement Survey [27] that identified, among other things, "most disliked" elements in the downtown center of the community near Cal Poly SLO. "Panhandlers" were at the top of the list, and "students" were in the top ten. These results led to a class discussion about who had a voice in identifying the desirable and undesirable features in the community in which they live, and how to conduct outreach effectively to target a more inclusive cross section of the community. In both of these Capstone projects, we assess higher levels of Bloom's Taxonomies. Specifically, social justice analysis in design development responds to cognitive domain levels of "evaluate" and "create" and affective domain levels "value" and "organize."

In these examples, we demonstrate the simultaneous progression and reinforcement from introducing concepts in the first-year classes to reinforcing and connecting in the third-year class, to utilizing these concepts during open-ended design development in the capstone classes. This progress establishes a trajectory of development and growth that aligns with the ability of graduates to demonstrate the PEOs in their early careers, as intended.

More, this progression allows entry of civil and environmental engineers into the workplace who are comfortable and confident in discussing social and environmental justice in the context of their engineering work, and who are able to incorporate these considerations effectively into their designs and the communities in which their design are built and utilized. As these engineers take their place in the work force, they will be well prepared to effect change and move the profession as a whole. Social and environmental justice should not be novel concepts, or uncomfortable considerations for engineers; they should not be held separate from the engineering decisions that affect a community. Engineering is experienced within a social context – it should be practiced and taught with social considerations integrated into the process.

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