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Teaching Environmental Justice Principles to Chemical Engineering Seniors: An Antiracist, Collaborative Approach

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Anna Marie (she/her) is a Ph.D. student in the Department of Chemical & Biomolecular Engineering at the University of Connecticut. Her work is related to thin-film fluid mechanics and nanosheet co-assembly for use in high-barrier polymer nanocomposites. Having completed the Graduate Certificate in College Instruction (GCCI) at UConn, she is preparing to teach at the university level upon graduation in late Spring 2021. Through her research laboratory, she has mentored more than a dozen undergraduate students who are under-represented minorities in STEM. Additionally, she has been involved with her school's Rainbow Center as well as anti-racist activism in both her department and outside of academia. Her goal is to bring social justice principles into STEM education and model what a queer, feminist, anti-racist engineer would be.

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Jennifer Pascal is an Assistant Professor in Residence at the University of Connecticut. She earned her PhD from Tennessee Technological University in 2011 and was then an NIH Academic Science Education and Research Training (ASERT) Postdoctoral Fellow at the University of New Mexico. Her research interests include the integration of fine arts and engineering and developing effective methods to teach transport phenomena.

Ms. Danielle Gan, University of Connecticut

Danielle Gan (she/her) is a senior undergraduate in the Department of Chemical & Biomolecular Engineering at the University of Connecticut with a minor in Global Environmental Change. She is currently assisting Dr. Kristina Wagstrom with research on the design and testing of an unmanned aerial vehicle that can monitor particulate matter. Danielle is a member of Citizens Climate Lobby, a grassroots environmental group that aims to influence climate policy. She is also a member of the Society of Women Engineers (SWE), as well as the Filipino American Student Association (FASA). After graduating, she hopes to combine her technical skills with her passion for the environment in the chemical engineering industry.

Mr. Justyn James Paquette Welsh, University of Connecticut

Justyn Welsh (he/him) is a senior undergraduate in the Department of Chemical & Biomolecular Engineering at the University of Connecticut with a minor in Entrepreneurship & Technology Innovation. His on-campus research consists of designing a Portable Air Pollution Monitor under Dr. Kristina Wagstrom, however, his involvement expands beyond just the School of Engineering. He is a recipient of the UConn IDEA Grant for a startup titled "breathe." to promote and execute stress relief through a weighted, scented blanket. He also served as a METAS (Mentoring, Educating, and Transforming to Achieve Success) mentor for incoming and transfer LatinX students, is a flute player in the UConn Concert Band, the Treasurer of the University's Engineering World Health Chapter, and a KUBE (Kids and UConn Bridging Education) Leader in which he designs and executes lesson plans for middle schoolers interested in STEM. Justyn hopes to get involved with the groundbreaking research in genetics, pharmaceuticals, or the aerospace industry as he prepares to graduate from UConn and begin to work on his Master's degree.

Mr. Thomas James Pauly, University of Connecticut

Thomas Pauly is a senior undergraduate studying Chemical Engineering in the department of Chemical and Biomolecular Engineering at the University of Connecticut with a minor in Environmental Engineering. He is both a highly motivated college student and an academically excelling learner. Thomas currently assists Dr. McCutcheon as an undergraduate teaching assistant for the course "CHEG 3128: Chemical Engineering Junior Laboratory" in the UConn School of Engineering. He is also an active undergraduate research assistant studying the economic impact of ground-level ozone concentrations on

soybean crop yields in Dr. Kristina Wagstrom's Computational Atmospheric Chemistry and Exposure (CACE) laboratory. For the past two summers, Thomas has worked two internships: the first as an engineering intern at Allnex in 2019, and the second as an Environment, Health and Safety Intern at Pfizer in 2020. Working at Pfizer especially developed Thomas's work ethic and passion for chemical engineering, influencing him to seek further related chemical engineering positions after graduation where he can apply the knowledge he has learned in school to the pharmaceutical or manufacturing industries. Thomas is now seeking a full-time position with an engineering firm starting summer 2021 where he can use his extensive analytical skills and proficiency with process modelling software and laboratory techniques to help solve problems that can change peoples' lives.

Patrick Paul, University of Connecticut

Patrick Paul (he/him) is a senior undergraduate in the Department of Chemical and Biomolecular Engineering at the University of Connecticut. His previous research experience includes multifunctional nanostructured materials for various applications, where he assisted in the experimentation of applying various nanocoatings to plastic films. Patrick also has served in multiple leadership positions for the UConn Chapter of the National Society of Black Engineers (NSBE).

Abstract

The aim of this project is to engage students with course material related to environmental justice principles using anti-racist pedagogy. In a senior-level Unit Operations and Process Simulation course for chemical engineers, students are asked to take a holistic approach to chemical plant design. However, previous iterations of this course did not ask students to consider the implications of building them: Who is making the decision to build these plants, and why are they doing so? Where are these chemical plants being built? Are they safe for the workers and the surrounding neighborhoods? Who gets to design these plants, and who will be maintaining these plants? If there's a difference between those groups, why?

To this end, we incorporated a one-week course module on environmental justice as it pertains to chemical engineering. In an effort to emulate anti-racist, feminist modes of instruction, we called upon a few of the students to form a "cogen" (co-generative dialogue) to assist us in developing and delivering the course materials for this week of class. Over the course of the semester, four students self-selected to be a part of this cogen, meeting with the instructor once per week to co-develop learning objectives, instructional strategies, forms of assessment, and course materials for this module. In doing so, we centered the narratives of the students who have been directly impacted by climate injustice and environmental racism, as well as students who have been involved in climate activism in their non-academic lives, in the delivery of the course materials. Collaboratively, the 4-student, 1-instructor cogen team co-developed course content relating to the role of chemical engineers in advancing awareness of environmental injustice and its local, national, and global impacts on public health, economic security, racist violence, mental health, and more.

By starting an in-class dialogue about the responsibilities of the members of our discipline, we hope to engage students in broader issues such as diversity, equity, and inclusion of Black, Indigenous, and People of Color (BIPOC) individuals within STEM fields as well as the disparities in access to housing, healthcare, and education among marginalized communities across this country.

Introduction and background

Anti-racist engineering education

There is a great need for anti-racist education at all levels of schooling. While STEM curricula are often overlooked for their perceived "neutrality" towards social justice issues, there are numerous design choices made by engineers and city planners every day which impact certain racial groups more than others. Environmental Justice (EJ) is defined as "the fair treatment and meaningful involvement of all people regardless of race, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies".[1] Environmental racism is the phenomenon were communities of color face disproportionate consequences of climate change, such as pollution, rising temperatures, rising sea levels, are more due to centuries of racist policies.[2] Essentially, there are numerous decisions being made by chemical engineers and their associates which directly affect the health of Black and brown communities, a component of engineering work that must be taught to college-level chemical engineering students.

Several anti-racist and feminist STEM pedagogies have been developed over the past decade.[3], [4] In the most basic form of intersectional feminist analysis, one can ask questions such as, who benefits from engineering? Who does not? Who bears the cost of engineering? Who does not? Diving into feminist technology studies, one can ask, what populations benefit from engineers' solutions, and what populations are overlooked? Why are these populations overlooked, and what populations bear unintended consequences or penalties of engineering solutions?
These questions help guide the discussion of basic engineering ethics with regard to what types of people deal with the benefits of, say, a wastewater treatment plant or a trash incinerator (mainly upper-class white people) and what types of people deal with the consequences of having such plants in their backyards (mainly, lower-class Black and Latinx people).

Additionally, in an "ethics of care" approach, one can ask questions such as, what are engineers' capacities for art and creativity? What are engineers' capacities for empathy? What are engineers' capacities for care? What is the role of social workers, activists, sociologists, feminist and anti-racist scholars, political scientists, and community members in "engineering" work? When teaching potentially difficult and sensitive topics such as environmental racism, it is critical to acknowledge the humanity of those being impacted.[5] When discussing racial violence specifically, instructors should center the experiences of those impacted and not attempt to abstract the issue to something happening against theoretical populations.[6] Finally, an instructor should strive to collaborate with those already doing the work in their community to combat social injustices.[7]

In the interest of modeling these anti-racist and feminist learning strategies, the authors of this paper—one instructor and four undergraduate students in an undergraduate unit operations class—collaborated on a one-week module on environmental justice for chemical engineers ("EJ Week"). In this course, students are asked to learn the technical skills required to design chemical production plants. However, previous iterations of this course did not ask students to consider the implications of building them: Who is making the decision to build these plants, and why are they doing so? Where are these chemical plants being built? Are they safe for the workers and the

surrounding neighborhoods? Who gets to design these plants, and who will be maintaining these plants? If there's a difference between those groups, why? By starting an in-class dialogue about the responsibilities of chemical engineers, we hoped to engage students in broader issues such as diversity, equity, and inclusion of Black, Indigenous, and People of Color (BIPOC) individuals within STEM fields as well as the disparities in access to housing, healthcare, and education among marginalized communities across America.

Context for learning

In a typical semester of Unit Operations and Process Simulation, students build on their prior knowledge of thermodynamics, reaction kinetics, and transport to look holistically at chemical production plants. Using Aspen Plus V11 simulation software accompanied by lecture materials explaining the basics of production-scale reactors, heat exchangers, pumps, turbines, and more, students get a glimpse of "real-world" chemical engineering applications. Students are given in-class example problems as well as homework assignments and a semester-long project which assess their ability to navigate Aspen Plus software and think critically about how the parameters of different unit operations (reactor temperature, pump discharge pressure, column stages, etc.) will impact a chemical engineering process. Deliverables gradually increase in complexity from those containing a single input and a single unit operation to those containing multiple inlet streams, multiple operations, recycle loops, process optimization solvers, and more. "Lectures" took place in a computer lab setting, where students could follow along with the instructor in Aspen Plus software and work independently or collaboratively on example problems or graded course deliverables.

The Fall 2020 edition of Unit Operations at this school featured 64 Senior chemical engineering undergraduate students, mainly comprised of "traditional" students (full-time students who lived on campus) but also numerous "non-traditional" students (part-time students, commuters, adult learners, etc.) Additionally, the course took place during a global pandemic, meaning the course was taught in an online, distance-learning format. The class took place in a synchronous format and met three times a week, with Monday periods devoted to a lecture provided by the instructor, Anna Marie, and Wednesday/Friday periods mainly devoted to in-class problem solving. Meaningfully, the course was also taught in a time where there was renewed interest in racial justice, during the resurgence of the Movement for Black Lives following the murders of George Floyd, Breonna Taylor, Tony McDade, and too many others by the hands of police officers. This factor, we feel, certainly lent itself to the discussions of racial injustice held throughout the course and during EJ Week.

Co-generative dialogues ("Cogen" teams)

In an effort to emulate anti-racist, feminist modes of instruction, a co-generative dialogue ("cogen") was used. Discussed most prominently by educator Christopher Emdin, cogens are "structured exchanges in which students and their teacher co-develop strategies for instruction that focus on the students' socioemotional and academic needs".[8] Essentially, a cogen team consists of the instructor and a small group of students who meet on a regular basis to discuss anything from the instructor's and students' perspectives on schooling to the development of novel course modules for the class. The ultimate purpose of forming a cogen is to have students work with the

instructor to guide the content and learning activities of an ongoing course. Ideally, the cogen team should be a representative sampling of the class as a whole; students of various socioeconomic backgrounds and academic abilities.

This anti-racist, collaborative approach to instruction provides a number of advantages. Giving students agency over their learning is a step towards the democratization of the learning process. Students are learning about what they care about, which will lead to them being more engaged with the course content. Through ongoing dialogue with students, the instructor gets quick, effective feedback on their teaching, and students feel as though their concerns are being adequately addressed by the instructor.

In his book, Emdin describes a cogen process that takes place over the course of an entire K-12 academic year. Our approach deviates slightly from this in that the cogen team was formed for the express purpose of creating EJ Week, a one-week module on environmental justice for this one-semester class. Our goals in creating this cogen were very similar to those of a typical cogen practice, however. Namely, our goals were to (a) embody anti-racist, feminist pedagogy in an engineering course (b) democratize class control and increase student agency over their learning (c) center the experiences of students who experience racial injustice, (d) empower students to lead classroom conversations and direct course development. Additionally, it was important for us to (e) call attention to an important 21st-century social justice issue, (f) enable students to "plug in" to ongoing environmental movements at the university and nearby local communities, and (g) engage students in intimate, personal discussions during the era of online instruction, modeling an "ethics of care" approach to learning.

Methods

Forming the EJ cogen team

On the first day of the Fall 2020 semester, the course's co-instructor (Anna Marie) called upon the students of her class to assist her in developing and delivering the course materials for EJ Week. Paired with a slide deck detailing the course expectations, deliverables, and schedule, a brief summary of the premise of EJ Week was proposed. "Yes, we are 'getting political'" read the PowerPoint presentation, next to an image of a raised fist colorized with blue-and-green iconography resembling the Americas. "When designing chemical plants, environmental health and safety needs to be considered. This includes the safety of Black lives."

In the interest of displaying transparency, honesty, and humility when discussing racial justice as a white instructor with class privilege, the goals of the cogen experience were clearly stated on the slides, with an emphasis on shared learning and deconstructing the student-teacher hierarchy; "I want to learn *with* and *from* you." Students were encouraged to join the cogen team by emailing Anna directly with a brief explanation of their experience, if any, with climate-related issues and leading classroom discussions on social justice issues. Students were given a one-week deadline to "apply" to be a part of the cogen. The requirements of the cogen team were also stated clearly; weekly meetings between Anna and the students to determine the learning objectives (what we'd like the class to take away from this module), instructional strategy (the in-class activities for EJ Week), and forms of assessment (the homework assignment and project deliverable associated with the module's learning objectives). In exchange for their increased educational labor compared to the rest of the course, students who self-select to take part in the cogen would be able to drop one homework assignment from their final grade.

Ultimately, four students—Danielle Gan, Patrick Paul, Justyn Welsh, and Thomas Pauly—offered to take part in the EJ cogen, writing to Anna about their prior experience with leading climate discussions. Danielle, a young woman of color pursuing a minor in global environmental change, had taken numerous courses about environmental science and policy and had worked with Citizens Climate Lobby, a grassroots activist group that works to lobby for climate change policies. Patrick was an executive board member of the university's National Society of Black Engineers (NSBE) chapter and had co-taught part of a class on fake environmental activism and greenwashing. Justyn was passionate about climate change and interested in its impacts on student mental health, and had also served as a student mentor through the university's Puerto Rican & Latin American Cultural Center. Finally, Thomas was pursuing a minor in environmental engineering and had taken courses in the Department of Sociology, giving him experience with discussing non-technical topics in a classroom setting. Under the guidance of Anna, a Ph.D. candidate in chemical engineering with a graduate certificate in college instruction (GCCI) from the UConn School of Neag, these four undergraduate students worked together to develop the content for an entire week of this unit operations course.

Developing course content (learning objectives, instructional strategy, assessments)

Over the course of 5 weeks, the cogen team met each Friday to develop the learning objectives, instructional strategy, and assessments for the environmental justice module. The first

session was primarily a brainstorming session, where Anna laid out the ground rules for discussion and the group listed out all of the topics and ideas relating to environmental justice that we wanted to be discussed in class. Central to this discussion were questions such as: What are we interested in discussing during EJ Week? How will we connect these topics to what we are already learning in this course? What is the most appropriate way to present anti-racist, feminist ideas in this context? What will the students be doing in class (the learning activities) and how will learning be assessed? Finally, yet crucially, what are the key deadlines in making sure this vision comes to fruition, and how can we develop timely goals for ourselves to make sure we have a full plan for EJ Week by the time it comes around? With these guiding questions, we established rough deadlines for when we would like to establish which aspects of course design (learning objectives, learning activities, and methods of assessment).

Through co-generative dialogue, the cogen team developed a set of learning objectives for EJ Week, which are presented below.

By the end of this module, students should be able to…

1. *Define* environmental justice/injustice and understand why and where it exists.
2. *Apply* environmental/sustainability considerations in the chemical engineering industry.
3. *Identify* how environmental injustice & climate change impact different scales (local, national, global).
4. *Identify* how climate change impacts different marginalized groups.
5. *Produce* at least one step towards a solution to either environmental injustice or climate change itself.

Not only are these learning objectives aligned with ABET criterion 3 for engineering students, they are focused on what would be most impactful for student learning in this setting. The undergraduate cogen members expressed that environmental issues are often seen as "happening elsewhere", such as the destruction of rainforests in a far-off country, and wanted to emphasize that environmental injustices were occurring in our own backyard. Hence, we placed a focus on EJ issues that were happening locally (in Connecticut), nationally (in the United States), and globally (across the world) in an effort to draw a direct line between all three scales. For example, having experience with living or doing activist work in towns such as Waterbury, Hartford, and Bridgeport, CT, the cogen team wanted to discuss how redlining practices and the placement of landfills, waste incinerators, wastewater treatment plants, and more were affecting Black and brown lives in our home state.

The instructional strategy for EJ Week was also developed collaboratively with students. A mainstay of anti-racist instructional methods is student-teacher dialogue, so the ability to engage students in conversation would lead to the highest level of understanding about EJ issues. Additionally, the cogen team wanted to bring in guest speakers from an undergraduate activist group to demonstrate ways in which students could "plug in" to existing environmental justice movements happening on their campus. However, there was also an entire lecture's worth of definitions, examples, and prior literature that the cogen team felt necessary to present before these conversations and guest lectures took place so that all 64 members of the class could be on the same page.

Therefore, it was decided that EJ Week would be broken up as follows (summarized in Figure 1):

- Monday's class period (10/26/2020) would consist of a lecture led by undergraduate cogen team members. This lecture would have the four student members trading off and discussing different aspects and examples of environmental injustice.
- Wednesday's class period (10/28/2020) would consist of four interactive Zoom breakout groups, each led by one undergraduate cogen team member. In each breakout group, students would work in small groups (<15 students each) to hold deeper conversations about different elements of environmental injustice.
- Friday's class period (10/30/2020) would consist of a guest presentation by two members of UCCO, followed by a 15-minute Q&A portion, where students could appreciate the perspective of a group leading in environmental activism. Topics would include environmental racism in Connecticut and Puerto Rico as well as the climate movement taking place on the university's campus.

Figure 1. Comparison of EJ week to the rest of the course

	Monday	**Wednesday**	**Friday**
Average Week in the Observed Unit Operations Course	Instructor-led lecture on a type of unit operation	In-class problem solving on technical ChemE problems, groups of 2-4	In-class problem solving on technical ChemE problems, groups of 2-4
Environmental Justice Week	Student-led lecture on environmental justice principles	In-class discussion on racial justice issues, groups of 12-15	Guest speakers from student activist group, follow-up Q&A

With regard to the topics of each Zoom breakout group session, each undergraduate cogen member had the opportunity to identify a "specialty", or subject area that they were most interested in sharing with their classmates. Dani, who had taken courses on environmental movements, was interested in "greenwashing", the practice of marketing products to appear environmentally-friendly when they aren't necessarily "green" in their production process. Justyn, who was passionate about human psychology, focused on the intersections of climate change and its impacts on human health, both mental and physical. Thomas, who had taken courses on sociology, was equipped to lead discussions on how environmental issues had disproportionate impacts on different minoritized groups, a pillar of environmental justice principles. Finally, Patrick, who had co-taught a course on fake environmental activism, was interested in using veganism as a lens through which engineers could view EJ work as their "personal responsibly" when corporations are largely to blame for the majority of environmental devastation. It was determined in the early cogen meetings that the 4 key topics that we were centering in on were Greenwashing, Mental Health, Socioeconomic Impact, and Vegan Capitalism, conversations which would be led by Dani, Justyn, Thomas, and Patrick, respectively. For Wednesday's class period, students were sorted into one of these four interactive Zoom breakout groups randomly.

To assess student learning, the key takeaways from the Monday lecture and each of the four interactive breakout sessions were worked into one homework assignment and one deliverable for the Chlorobenzene Plant project. In place of a typical Aspen Plus-based homework assignment, students were instead instructed to create a discussion thread using Blackboard, the online classroom platform that was used for this course. There were four main "boards" to post on, each corresponding to the four cogen member's specialty and each with their own cogen-produced discussion questions. Possible questions included: Are there actions that communities can take to increase the environmental viability of their area? Are individuals responsible for regulating the environmental risk factors or should the government be primarily responsible for this? If a violation of environmental justice is found, what might the process include to remedy the issue? Or, in the case of the mental health specialty: How might people's thoughts be affected when surrounded by pollution or seeing all the news in the world regarding this topic (think just thoughts, but not chemistry)? What do you think an engineer's role is in shaping their society's mental health?

In their online thread, students would respond to these discussion questions, which assessed their understanding of the lecture concepts and tied them back to the work they may one day be doing as chemical engineers. Students were encouraged to post to the board corresponding to the breakout group that they were randomly assigned into, but were allowed to post in a different board if the topic interested them more. Each post had to answer each question posed by the cogen team and had to bring in one original source—news article, academic paper, YouTube video, etc.—to contribute to the conversation about environmental justice. After all students had made their first discussion board post, they were then assigned to comment on two of their peers' posts, at least one of which required to be in a different board than the one they originally posted in. This was meant to generate discussion between students in a safe and respectful environment.

In the project deliverable associated with EJ Week, students were asked to use Aspen Plus software to determine the CO2 equivalent carbon output of their chlorobenzene production plant (a tutorial for how to do this would be provided the following week of class) and respond to pre-made discussion questions about this number. Aspen Plus also reports which unit operations costed the most to install and which unit operations contributed the most to global climate emissions. The deliverable's discussion questions included:

1. Which blocks are the most expensive to make and install? Does this surprise you?
2. Which blocks have the highest annual utility cost? Does this surprise you?
3. Which utilities have the biggest contribution to climate injustice?
4. What is the total CO2 equivalent output of the chlorobenzene plant in tonnes per year? What does this cost your company in $/year? Is this a fair tradeoff?
5. Based on your answers from questions 1-4, what are some changes you could implement in your plant to reduce energy costs and your carbon output?

In general, students were more engaged in the in-class discussions during EJ Week than any normal week of lecture. Additionally, the interactive nature of the discussion board posts allowed students to grow in their understanding of the subject, in part thanks to the iterative nature of the assignment compared to a traditional homework assignment, and in part thanks to feedback from their peers on their responses to the discussion questions. Students also self-reported that

more assignments should be assessed this way in general, regardless of the discussion topic, in the post-semester student-teacher evalutations. Finally, students demonstrably understood the ethical nature of the questions being asked in the project deliverable portion of EJ Week, providing nuanced answers that acknowledged the environmental cost of their chlorobenzene plant and considering ways to reduce the most energy-intensive unit operations. For future iterations of this practice, a comprehensive study on the specific learning goals that were achieved will be completed. The results of this study will be presented at ASEE 2022.

In summary, the cogen team was able to plan out one full week of a senior-level chemical engineering course while connecting the class content to social justice principles. With the ideas and passions of four undergraduate cogen team members and one instructor who kept discussions on track, the team was able to create a novel course module while respecting the needs and experiences of diverse students.

Now, the authors would like to speak more personally about the aspects of the course that they had more control over.

Cogen Member Experiences

Dani

My main motivation for volunteering to be part of this Cogen was to share my passion for the environment with others. If I could make at least one person think critically about the decisions they made when it came to sustainability, I would achieve my goal. During Wednesday's breakout session, I decided to delve deeper into greenwashing.

As someone who isn't well-versed with leading discussions, I took more of a structured approach. I created a presentation that began with a background information lecture on what greenwashing was, common signs of greenwashing, and how to prevent yourself from buying into it. This was followed with an activity where they watched "greenwashed" ads and filled out a table on the different greenwashing rhetorics. I also gave them time to discuss how they felt about greenwashing and what they could do to prevent greenwashing to tie it back into actionable items they could do as up-and-coming chemical engineers. To finish it off, I had my classmates collaborate on a mini-project in which they made their own greenwashed ad and presented it to the class. This was meant to be a light-hearted activity after Monday's somewhat gloomy lecture. Participation was great throughout the session, but the collaborative activity at the end was when people really got involved. My favorite part about Wednesday was that people were able to take what they learned and creatively demonstrate that information while also having fun.

Environmental Justice Week will be something that I remember for the rest of my life. The hard-working, passionate people I had the opportunity to work with made it such a valuable experience. I hope that this becomes a regular academic staple not just in the Chemical Engineering department, but in other departments and other schools as well.

Justyn

In the beginning of this semester, this was an opportunity that I definitely think went under the radar. Students were given an opportunity to teach the class something entirely new to our Chemical Engineering curriculum that was not derivation, theory, or calculation. I honestly do not understand to this day why students did not jump at the opportunity to do this. Either way, I made sure to draft my email to get in the cogen team and get to work on this topic. Initially, I was thinking of the Great Barrier Reef getting bleached and closer to dying. That was my motive for joining, however, it continued to grow and evolve as we bounced ideas off of each other's heads. As time went on, getting the autonomy to create a lesson plan from start to finish helped to grow my interest in the topic.

We supplemented our lecture with breakout rooms based on four topics that each of us developed based on our personal interests. My particular topic was how Environmental Injustice can not only have a physical impact, but also a psychological one. I grew up in a house relatively conscious of mental health as my father works in the CT Department of Mental Health, however, I learned so much more just doing the research to make accurate slides. I am speaking for myself

here, however, I believe that everyone else on the team can definitely say the same for their topics. This was an excellent supplement to the slides, however, I wished there was just slightly more participation with my aspect of it (everyone else seemed to do fine in that department though). Students did seem interested, but I believe the weight of the topic was a deterrent from their full participation.

Having a guest speaker was a great way to break up the fatigue of our voices for the week, and the presentation from student activists gave another angle that we did not give as much attention during the planning phase. Inviting a guest speaking group that consistently does lectures and informationals off these topics was a great perspective to have for this project. This activist group is planning to do more in class lectures following the success of this cogen.

My all-in-all thoughts is that this should absolutely stay in Unit Operations and Process Simulation for the following iterations of this course. Growing from that, this is something that could seriously benefit all the engineering courses in the curriculum. It improves interaction as students are learning from peers that they see daily over the course of four years and are more comfortable with. Furthermore, you are subconsciously learning from the research, rather than just regurgitating it for the slides. There is a driving factor behind the motive to give your peers the best presentation as possible that encourages you to do quality research and learning. This did so well at breaking up a simulation-based course, however, this would do so much for a derivation-based course where students get tired of looking at equations all day. One of the big reasons that students lose steam is they get tired of a repetitive teaching format, and this gives a perfect segway to keep learning fresh. There is no limit to the positive things I could say about this experience, but I want to stress the fact that this should be in more engineering courses going forward.

Thomas

Overall, I could not have been happier with the outcome of this "cogen" experience. Upon joining the team back in September 2020, I did not know what to expect from involvement in such a project - this would be my first time accepting the undertaking of co-teaching a university level course. However, the opportunity to educate my peers on a topic of growing significance within the past few decades was calling my name, and I knew right away that I would not regret the choice of teaching my own classmates about environmental justice and its ties to chemical engineering. Now, after completing the week-long plan of broadening my classmates' understanding of environmental justice, I can confidently say that the task was both rewarding and insightful.

To begin, Monday's "Lecture day" was developed in a manner in which each team member focused on specific subject matter within the topic of environmental justice/environmental racism. A 30-slide Google slides presentation was formed collectively, where each cogen member was responsible for presenting their section to the class via screen sharing on Zoom. The four major topics that the slideshow focused on were 1) mental health and its relation to environmental justice, 2) greenwashing, 3) the rise of vegan capitalism, and 4) the socio-economic impact of environmental injustice. At the end of the presentation, the week's homework assignment was described in detail, which involved use of the discussion board feature on Blackboard to facilitate

conversation on the presented material. The lecture as a whole was very informative and I think the class in its entirety thoroughly enjoyed the opportunity to increase their understanding of the topic. Similarly, I appreciated the time I was allotted to take the stage and inform 60 students on environmental justice. With that being said, I can almost guarantee that each student in the class walked away with a better understanding of the subject.

The week was continued with an "Interactive day", which was my personal favorite of the three sections in the cogen module. During class time on Wednesday, each student was placed into one of four breakout groups within Zoom, with each group being based on one of the respective topics outlined in Monday's slideshow. Danielle, Patrick, Justyn and myself each prepared what we coined a "learning module" that contained informational videos, articles, definitions, case studies, and discussions surrounding our topic of study. These breakout sessions lasted around fifty minutes, and from my experience, they progressed smoothly and generated much discussion among the colleagues in my group. Rather than one-sentence answers to the questions I proposed during the session, multiple students were able to communicate elaborate thoughts on the subject matter presented, with many responding to each other's comments and creating interesting conversations. I finished my breakout room session on Wednesday with a newfound understanding of how students within my own class experience and witness environmental justice within our own cities in the state of Connecticut. I also was surprised by the number of original and effective ways that my classmates proposed in order to approach the issue of environmental injustice and create change in the communities that are suffering the most.

Finally, the week concluded with the hosting of two guest speakers from a grassroots movement for social and climate justice within the campus community. This presentation provided the class with further insight into environmental injustices occurring in surrounding communities, and detailed the ways in which environmental injustice disproportionately affects minority and low-income dominated areas in both Connecticut and around the world. I think that hosting these guest speakers was a great addition to the cogen week, as it provided an understanding of the issue from the perspective of two young people who have a background in being environmental activists themselves.

My final thoughts on the cogen experience are that participation in such a project was extremely beneficial to both the cogen team and the entire Unit Operations and Process Simulation class as a whole. It is without a doubt in my mind that a week (or more) dedicated to the topic of environmental justice should remain in the course curriculum for future semesters. Cogen week was so successful with Anna Marie LaChance that I would strongly recommend other engineering courses at the university to offer the experience as well. If environmental justice can be tied to chemical engineering, it can most certainly be tied to the other engineering disciplines being offered. Oftentimes, engineering courses provide students with a redundant, mundane curriculum, so incorporating a cogen week into these courses could serve as a method to effectively re-engage students into the course. Specifically, our cogen was engaging due to the fact that it encouraged interaction between students with the same major, making peers more comfortable with speaking to each other about important topics that need addressing. As for my personal benefit from teaching the course, I found that I was able to learn from the presented material myself in the process of researching and teaching the information. Becoming more aware of issues around me allowed me to have a better understanding of just how many injustices exist in the world today. Furthermore,

the fact that I was going to be teaching my peers and others I care about inspired me to give my all on forming this module and producing a quality product. It was rewarding to be able to have a drive to work so hard in order to benefit each and every one of my classmates. Overall, I am very grateful to have been involved with the cogen experience during my time as an undergraduate chemical engineering major, and I thank Anna Marie LaChance for the opportunity to educate myself and my peers.

Patrick

When the opportunity to participate in this cogen experience was presented to us at the beginning of the semester, initially I didn't consider it. When I was made aware of the incentives, along with my own personal feelings on environmental justice, I took it as a call to action. To me, the opportunity and its benefits were very low-key, and when I told my other classmates about what I was doing they felt as if they missed the opportunity as well. My main intention when participating was to present to my classmates a better understanding of the nuances of several environmental movements. I wanted my words to resonate with them in a way that left them knowing that they have the responsibility as engineers to think critically about these issues and not let popular opinion sway them. When we were first told about the cogen, this is what I felt that I could contribute.

The breakout sessions we did on Wednesday were a positive experience from my end. A positive from the preparation side of things was that we were given the freedom to set up our breakout session the way we wanted to. Given my past experience teaching a class, this gave me the ability to prepare a lesson in my own style that had been curated from 2 semesters of leading a discussion-based class. What this did is provided me the space as a student to communicate with my peers on an equal level so our discussion was more intimate and more people felt comfortable enough to engage. With the added familiarity from being in the same core classes for at least 4 semesters at that point, we were able to have a conversation about the specific issue that I was presenting on. This does however run the risk of the conversation veering off topic, but with an outline I would just move onto the next topic. The level of engagement was fair, about half of the people in the breakout room were contributing significantly to the discussion; contributing more than "yes", "I agree", or a head nod.

Anna

EJ Week turned out to be a resounding success and a great learning experience. The four students who self-selected to help design EJ Week all brought their own unique perspectives to the table while making the course relevant to the interests of their peers. I had some content planned for that week, but the cogen team was able to bring their experiences with environmental injustice and climate organizing, which ended up being much more impactful for the rest of the class. In particular, one cogen member was from Waterbury, CT and presented on some specific instances of pollution in the area. Towards the end of our Monday lecture, another student, a young Black man who happened to be from Waterbury, expressed some frustration that he wasn't sure how to get involved with the climate movement in his hometown, but our cogen

member was able to connect him with a Waterbury activist who was working on that very subject. This is just one example of the real-world connections that I would have never been able to make alone; so many students are seeking answers as to how they could tackle climate change, but by having a semi-formal space where two engineers from different social groups could discuss their passions, students could get solutions to the problems that their community is specifically facing. Conversations like this will be something I very intentionally build into future iterations of this course.

One of the challenges I faced as the instructor was allowing for flexibility and giving up my control over the course. Going into this process, I knew that there would be a tension between allowing students to direct the content (e.g. the learning topics, in-class activities, and homework questions) while also having to satisfy very real requirements such as having the content ready on time, integrating the newly-developed content to the already-prepared curriculum, and how all of this would impact my end-of-semester student-teacher evaluations (which are extremely important for an early-career educator, particularly one from a marginalized identity). I was putting a lot of trust in these students to make something amazing, and it felt incredibly vulnerable.

The experience worked out in the end, but it also presented challenges to my values when trying to be fair to all the students in the course. I had initially planned to allow the cogen team to drop their grade for one homework assignment in exchange for their education labor. However, about halfway through the development process, we came to the agreement that they should be allowed to drop two homework assignments, on the condition that they submit *something* for grading rather than nothing. This was a difficult decision since I was already allowing the rest of the class to drop two homework assignments out of a total of eight, but I held true to my believe that instructors should allow for this kind of flexibility and kindness when considering what the students who are taking your course are going through.

However, there was one magical moment for me that came out of that same conversation. I had asked the cogen team if this was taking up too much of their time and was an undue burden on them. Patrick responded with something along the lines of, “yeah, it’s taking up a lot of time, but it’s something I actually like doing, so I really don’t mind”. The rest wholeheartedly agreed. This set off alarm bells in my mind; it was exactly what every educator dreams of, to have your students report that they love what they’re doing so much that they can accept the difficulty of the content. *I want every assignment in every course the feel like this*, I thought.

In my vision for the future of engineering education, students from all walks of life are allowed the agency, flexibility, and creativity to pursue career paths that interest them; their interests are respected and honored and they are able to use their unique backgrounds to make positive contributions to society; curriculums are set up to be well-rounded and incorporate social justice principles; and engineering students are able to connect with peers and mentors across education levels, departments, and even other fields to create a truly interdisciplinary and well-rounded education, rather than thinking of social justice as separate from engineering. Having taught based on this model of pedagogy, and seeing it work out so well, I now fully believe that this future is completely possible!

Summary, Lessons Learned & Future Work

In summary, our group was able to embody anti-racist, feminist pedagogy in a core chemical engineering course by discussing environmental justice principles. Throughout Environmental Justice Week, we informed students on how their engineering decisions could impact communities disproportionately along lines of race & class and assessed their knowledge through homework and project deliverables, as well as thought-provoking, intimate, and respectful conversations, which is even more notable to have been executed in the era of online instruction. Through the use of co-generative dialogues, we centered the experiences of students of color in these conversations, thereby empowering students to lead class conversations and taking steps towards democratizing control of the course content. By inviting guest speakers from outside the discipline of chemical engineering, we enabled students to plug into environmental movements and engaged students with potential interdisciplinary career options. In the end, we established a modular instructional strategy where topics (greenwashing, mental health, etc.) could potentially be swapped out with other intersecting areas depending on student interest & the needs of future cogen teams, further establishing the practice of centering the needs of diverse and underrepresented student populations.

This first attempt at co-generative dialogues did present some learning experiences and opportunities for improvement, however. First, the development of novel, student-generated course content takes a lot of time on behalf the instructor and the cogen team. In the end, the four members of the cogen team met with the instructor (Anna) once per week for six weeks to fully develop the content for one week of the course, on top of regular class meetings and the busy schedules of all parties. It is our hope that future iterations of the course could use the same basic "skeleton" of EJ week (student lecture, breakout discussions, guest speakers) where the specific topics could be swapped out depending on the needs and interests of the new cogen team. Additionally, this particular method of executing co-generative dialogues does not present much scalability; class sizes much larger than ~100 students could present challenges such as limited intimacy of discussions and/or opportunities for student feedback. This particular method may also be more suitable to more senior students, who are better at developing undergraduate-level lecture content and having mature, respectful discussions about sensitive issues, as opposed to college freshman. Finally, the anti-racist content of the course could have been better-integrated into the course as a whole, with regular assessment of student progress toward anti-racist learning goals, rather than being condensed into a single course module and assessed in a small handful of deliverables. In future iterations of this course, specific learning goals and student outcomes will not only be more robust, but will be assessed regularly throughout the semester with feedback from the instructor and potentially the cogen team. A more complete study of EJ Week and the use of co-generative dialogues in this Unit Operations course is being planned for Fall 2021 and the results will be presented at the ASEE 2022 Annual Conference.

As the instructors of EJ Week, our key takeaways from this experience are as follows: Engineering and social justice are inseparable, and a well-rounded, interdisciplinary, anti-racist engineering education is possible. Based on the engagement we observed during EJ Week, engineering students are starved for conversations about social justice. Finally, engineering students, especially those who have been historically excluded in STEM, deserve to have their voices heard and to have agency over their learning.

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