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Designing and Implementing a Workshop on the Intersection between Social Justice and Engineering

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Designing and implementing a workshop on the intersection between social justice and engineering

POSITIONALITY STATEMENT

We acknowledge that the authors are all in varying positions of privilege. The university at which we are implementing this initiative is a primarily white, private institution in the United States. We are also located in a state in which such topics are relatively open for discussion in educational settings. Although the authors hold different identities in gender identity, race, ethnicity, sexual orientation, socioeconomic status, and more, we are far from representative of the larger population and recognize the need for many more voices in this type of work.

MOTIVATION

2020 was a catalyst for change in higher education

2020 was a tumultuous year in the United States (U.S.), when systemic racism, a pandemic, and violence against unarmed Black people brought the nation to a racial reckoning. Structural racism in the form of redlining, lower pay, unequal access to education and healthcare, and many more forms of institutionalized bias laid a foundation for disproportionate negative health and environmental impacts for minoritized groups in the U.S. [1], [2]. The coronavirus pandemic, whose peak in 2020 in particular had a disproportionate effect on Black and Latinx patients, highlighted the inequalities faced by these populations who often had higher exposure to the virus, more underlying health conditions, and less access to healthcare than their white counterparts [3]–[5]. The Black Lives Matter movement and the protests following the murders of Ahmaud Arbery, George Floyd, Andre Hill, Breonna Taylor, and many others brought visibility to targeted, racially motivated killings of Black Americans [6]–[8]. The confluence of these events had a profound impact on Black and Brown people in the U.S. and was keenly felt on college campuses where the stress and trauma of these events compounded the already imbedded injustice in the education system [9], [10].

A call for change echoed through higher education institutions, where there was a need for increased efforts in diversity, equity, inclusion, and anti-racist practices [11]. Diversity and inclusion training has been on the rise in the past decade [12]. With the return to in-person learning following the initial pandemic-related lockdowns of 2020, many institutions increased offerings of diversity trainings for faculty and staff. But whether those diversity trainings were effective is up for debate, with evidence pointing to some promising initiatives but few institutional changes that disrupt racism [13]–[15] and some well-intentioned trainings exacerbating the problem of bias [16]. In turn, many campuses moved to embracing student-centered pedagogies. Tools and resources, such as the “Advancing Inclusion and Anti-Racism in the College Classroom: A rubric and resource guide for instructors” [17] and “Toward an antiracist engineering classroom for 2020 and beyond: A starter kit,” [18] were developed to help

faculty reflect on their identity and positionality, consider their students' lived experiences, and move toward anti-racist pedagogy, assessments, and inclusive teaching practices.

Within our department, there was a strong desire to make lasting changes to the culture and curriculum. These efforts were driven by our graduate students with support from our faculty, and included the establishment of an Anti-Racism, Diversity, Equity, and Inclusion (ARDEI) Committee, collection of data through a climate survey to gauge the needs of the department's members, and creation of efforts to include anti-racism and social justice in the department's curriculum and research [19]. The latter of these initiatives was both the first initiative taken in the department and is the focus of this paper.

There were few established examples for how to increase awareness of the connections between research and anti-racism

Our goal was for researchers in our department to be equipped to connect their research to anti-racism and social justice. This meant that we needed to help them move beyond considering not only the technical merits or impacts of their work, but to also consider the social, health, political, and/or environmental impacts of their work. This analysis of the context in which engineering research and solutions are embedded is not commonly done in engineering, where the technical aspects are often divorced from the societal aspects [20]. The question of how to teach researchers to make these connections is not settled, but there is an increasing number of resources showing how engineering and social justice are connected:

- General engineering and social justice
    - Free Radicals "Science Under the Scope" [21]
    - Donna Riley's *Engineering and Social Justice* book [22]
    - Caroline Baillie's "Engineering and Social Justice" chapter [23]
    - ASEE workshop on the "Foundations of Social Justice for Engineers" [24]

- Specific case studies in fields
    - Case study bioengineering ethics "SUMO-1" [25]
    - *Coded Bias* documentary [26]
    - Nicholas Sakellariou's "A Framework for Social Justice in Renewable Energy Engineering" chapter [27]

This area is emerging. There are several scholars documenting their attempts at adding social justice to the engineering courses [28]–[31], though not yet in engineering research, and it is yet to be seen whether educational interventions in these courses will have a beneficial impact on developing socially conscious engineers.

A workshop was developed to give researchers the confidence and a framework to interrogate their work through an anti-racist and social justice lens

Desiring a way to engage their fellow researchers, members of the department developed a workshop to encourage reflection on past injustices in engineering and scientific research as well as how they might incorporate anti-racism and justice in their work. Pulling together resources on workshop design, active learning pedagogies, and inclusive teaching principles, the workshop organizers attempted to build a *Contextualizing Your Research* workshop that was engaging, effective, and appropriate for a group of researchers that included faculty, post-docs, and graduate students.

The workshop, once created, can be repeated each year for new cohorts of researchers. Post-workshop surveys help assess which components of the workshop are effective and which can benefit from revision. Our workshops, which started in 2020, were held over Zoom due to COVID-19 related restrictions impacting in-person events. They stayed over Zoom during the next two iterations to remain accessible to participants that were unable to engage in in-person events. However, we feel that the workshops, as designed, would translate well to in-person delivery. Here, we highlight the workshop construction and positive impact on the participants to encourage and enable other engineering departments to utilize our workshop as a starting point for their own.

METHODS

Workshop participation was open to all department members

The workshop was open to graduate students, postdoctoral fellows, staff, and faculty. Graduate students were primarily from the host department, Department of Chemical and Biological Engineering, but any who work in labs housed in the department were welcome to join given the relevance of their research. Participants were recruited via email advertisements to department listservs, vocal encouragement from faculty members to their research groups, and direct advertising to faculty in faculty meetings.

Workshop structure aimed to facilitate participant engagement with content and peers

The workshop consisted of six components, delivered virtually: pre-work, community guidelines, anti-racism toolkit, introduction to research justice, case study breakout rooms, and conclusion. The pre-work included general guidelines and helpful sources to prepare participants, as well as case-study specific reading in 2021 and 2022. At the beginning of the workshop, a set of community guidelines was shared in order to encourage participation and discourage personal attacks. Because there were clear power dynamics present, such as faculty to graduate student, we explicitly addressed such dynamics and stressed that space should be made for everyone to participate comfortably. We then introduced an Anti-Racism Toolkit to ensure that all participants entered discussions with the same vocabulary. The terms were condensed

each subsequent year to highlight only those that we found the most relevant. In 2022, the defined terms were: white privilege, individual racism, systemic racism, anti-racism, ableism, research justice, and accessibility. The final portion of the introduction was an introduction to research justice. We sourced this section from the Free Radicals Collective. [32] The questions we asked people to consider were:

1. Why are you interested in the topic of your research?
2. What are the potential applications of your research (in the short and long term)?
3. Who is most likely to benefit from these applications? Who is most likely to be harmed?
4. Who is funding your research and why are they funding it?
5. Are there ways to shift your research to make it more sustainable, or more inclusive of low-income, queer, disabled, and/or communities of color?

After the introductory presentation, we had a short break and then sent participants to their respective breakout rooms. A thorough discussion of these breakout rooms is in the next sections. The workshop ended with everyone returning to the main room for final reflections. In 2020, we instructed one person from each group to briefly summarize their study, and in 2021, we condensed this to ask one person to state one concept their group learned. In 2022, we formalized the conclusion further and directed participants to write out a brief reflective statement to share in the main room.

Workshop design strategies used within each component were guided by literature

Each workshop component utilized a variety of strategies [33] to ensure active participation and creation of a safe environment (Table 1).

Table 1. Workshop features selected during the design of the workshop.

Workshop Design Strategies	How it was employed	Literature Basis
Common vocabulary	The workshop *pre-work* and *introduction* component(s) contained definitions of common diversity, equity, and inclusion (DEI) terms to ensure a common meaning was understood.	A common vocabulary can help participants feel comfortable using appropriate words to engage in discussion. Learning the meaning of these terms can help those holding a majority identity understand the experiences of those holding a historically minoritized or excluded identity. [34]
Community guidelines that promote inclusion and address power dynamics	The workshop *pre-work* and *introduction* component(s) contained a list of discussion norms that addressed engaging in conversation in a productive, respectful way that aids in learning.	The use of community guidelines establishes a framework for engaging in productive conversation. The guidelines should attempt to address inequities that often occur when majority identity holding

	Participants were asked to reflect on these norms at the outset of the workshop and consider their own positionality and how, if they hold a position of power, they might make space for those who do not.	individuals engage in discussions with minority identity holding individuals. [35], [36]
Reflective questions	The workshop *pre-work* and *case study* components presented participants with media (usually in the form of articles or videos) on the case study topic, then utilized reflective questions aimed to engage participants in critical thinking about media that was presented.	Reflection as an active learning technique encourages learners to make connections to past experiences or prior knowledge, and sometimes challenge their prior conceptions. When engaging with social justice topics, the learners may need to confront their own biases. [37]
Small group discussion	The workshop *case study* compon engaged participants in active dis the reflective questions in a small setting.	The cooperative learning technique of discussion encourages critical thinking and deeper learning than passive listening during the workshop. Small groups encourage participation of those that might not participate in a larger group setting. [38]

A common vocabulary of ARDEI-related definitions and community guidelines for discussion were established

In advance of the workshop, in order to get participants on the same page regarding definitions of ARDEI-related vocabulary and to set a precedent for respectful conversations of these difficult topics, we shared a set of definitions (Table 2) and community guidelines (Table 3) with participants. We also went over these again at the start of the workshop.

Table 2. Definitions of ARDEI-related vocabulary used for workshop.

Term	Definition	Reference
Ableism	The discrimination of and social prejudice against people with disabilities based on the belief that typical abilities are superior.	[39]
Allyship	The practice of emphasizing inclusion and human rights by members of an "in" group, to advance the interests of an oppressed or marginalized "out" group.	[40]
Anti-Racism	An active and conscious effort to work against multidimensional aspects of racism.	[41]
Bias	A particular tendency, trend, inclination, feeling, or opinion, especially one that is preconceived or unreasoned.	[42]
BIPOC	Black, Indigenous, People of Color, meant to acknowledge that not all people of color face equal levels of injustice	[43]
Diversity	The presence of different and multiple characteristics that make up individual and collective identities, including race, gender, age, religion, sexual orientation, ethnicity, national origin, socioeconomic status, language, and physical ability.	[44]
Equity	The process of identifying and removing the barriers that create disparities in the access to resources and means, and the achievement of fair treatment and equal opportunities to thrive.	[44]
Inclusion	Creating environments in which any individual or group can be and feel welcomed, respected, supported, and valued to participate fully.	[44]
Individual Racism	The beliefs, attitudes, and actions of individual that support or perpetuate racism; can occur at both an unconscious and conscious level, and can be both active and passive.	[45]
Positionality	Refers to the how differences in social position and power shape identities and access in society.	[46]
Racism	One group having the power to carry out systematic discrimination through the institutional policies and practices of the society and by shaping the cultural beliefs and values that support those racist policies and practices.	[47]
Systemic Racism	Racism that exists across a society within, and between institutions/organizations across society.	[45]
Unconscious Bias	Social stereotypes about certain groups of people that individuals form outside their own conscious awareness.	[48]
White Privilege	The unquestioned and unearned set of advantages, entitlements, benefits, and choices bestowed upon people solely because they are white.	[49]

Table 3. Community guidelines for discussion used for workshop.

Community Guideline	Explanation	Reference
Avoid assumptions	Avoid assumptions about any member of the class or generalizations about social groups. Do not ask individuals to speak for their (perceived) social group.	[50]
Use "I" language	Understand that others will come to these discussions with different experiences from yours. Be careful about assumptions and generalizations you make based only on your own experience. When speaking about your own experiences, use "I" statements to clarify for whom you are speaking for–yourself.	[51]
Treat others how they ask to be treated	Speak with care. If you learn that something you've said was experienced as disrespectful or marginalizing, listen carefully and try to understand that perspective. Learn how you can do better in the future.	[51]
Be curious and ask respectfully	Don't interrupt, turn to technology, or engage in private conversations while others are speaking. Use attentive, courteous body language. Comments that you make (whether asking for clarification, sharing critiques, or expanding on a point) should reflect that you have paid attention to the previous speakers' comments.	[51]
Listen actively	Listen actively and with an ear to understanding others' views. (Don't just think about what you are going to say while someone else is talking.)	[50]
Ideas, not individuals	Speak to an individual's ideas, not their entire person.	[51]
Encourage learning	Be open to changing your perspectives based on what you learn from others. Try to explore new ideas and possibilities. Think critically about the factors that have shaped your perspectives. Seriously consider points-of-view that differ from your current thinking.	[51]
Acknowledge and apologize for mistakes	Understand that we are bound to make mistakes in this space, as anyone does when approaching complex tasks or learning new skills. Strive to see your mistakes and others' as valuable elements of the learning process. If you make a mistake, just acknowledge it, apologize for it, and learn from it.	[51]
Make space for everyone to speak	Share responsibility for including all voices in the conversation. If you tend to have a lot to say, make sure you leave sufficient space to hear from others. In this case, consider the "you-then-two" rule: let at least two other people speak after you before you speak again. This prevents any one person from dominating the conversation and gives everybody a chance to be heard and to listen. If you tend to stay quiet in group discussions, challenge yourself to contribute so others can learn from you.	[51]

Case studies were developed to highlight inequities in core chemical engineering research areas within the department

Since participants would spend the majority of their time discussing the case studies during the workshop, we chose to create four studies that differed greatly in topic area but complemented the core topical areas of chemical engineering research within the department (Table 4). These initial case studies were used for two years and then four more were designed by the organizing committee for subsequent use and to ensure participants did not repeat previous case studies. In 2020 and 2021, the four case study topics were: Henrietta Lacks, clean water access, plastics, and air pollution. In 2022, the case study topics were: racism in medical research, outsourcing pollution, chemical plants, and metal extraction. In 2020, case study worksheets were provided to participants via Google Docs where each group filled out a blank worksheet. For the purpose of longevity and formalization, in 2021 and 2022, we translated case studies to Canvas learning management software pages, where participants could advance through the sections and take notes on a blank worksheet with only the questions. For each section, a time limit was designated to help keep groups on track and complete the study within the allotted workshop time. The case studies consisted of summarized articles, links to external sources for participants to read, and discussion questions. The readings were either assigned to individuals to read and then summarize to the group or read out loud as a group. The discussion questions were deliberated in the group and a notetaker was designated to fill out the blank worksheet to keep track of thoughts. As previously stated, the concluding direction for groups each year changed. For 2022 case studies, groups were asked to write a succinct answer to a specific question encouraging participants to reflect on their own research. After each year's workshop, all participants were given access to all of the case studies and their corresponding materials from that year to explore those of interest and more direct relation to their research in their own time.

Table 4. Case study summary and relation to chemical engineering. Case studies separated by year(s) of use.

Case Study	Background and Content Summary	Chemical Engineering Research Topics and Applications
2020-2021 Case Studies		
Plastics Based partly on "Louisiana Town Rebels Against a Chemical Giant" [52]	Chemical plants manufacture polymers such as neoprene. Cancer risk near the neoprene plant is 700 times the national average. In 2010, the EPA completed its safe level of chloroprene exposure and the levels near the plant were more than 150 times higher.	Topics/applications: sustainability engineering, polymer material use and processing, sustainable plastic polymers
Air Pollution and Climate Change	US census data reveals communities of color are more likely to be exposed to pollution and the effects of climate change than white populations.	Topics: air quality systems engineering, climate mitigation technology, alternative energy technology, energy analysis

Based partly on "The Environmental Justice Movement" [53]	Communities of color are routinely targeted to host facilities like landfills with negative environmental impacts.	Applications: carbon sequestration, PV solar power deployment
Henrietta Lacks Based partly on "Henrietta Lacks' 'Immortal' Cells" [54]	Cancer cells harvested from Henrietta Lacks' tumor without her consent or knowledge became the first immortal line of cells to grow in culture and were the first human biological materials bought and sold. Her cells are the basis of a multi-billion-dollar industry from which she and her family have received minimal if any profits from.	Use of identifiable collected biospecimens for broad research use. Topics: Biotechnology and synthetic biology, biomanufacturing, biomolecular engineering, bioinformatics
Clean Water Access Based partly on "They Grow the Nation's Food, but They Can't Drink the Water" [55]	East Orosi is one of many small California communities faced with unsafe groundwater, with nitrate levels that often exceed federal health standards. The main source of nitrate contamination is the use of nitrogen-containing chemical fertilizers. The residents of East Orosi are mostly low income, Latino families, who are more likely to lack access to clean water.	Topics: water quality systems engineering, water purification technology, sustainable water use Applications: designing water reservoirs, sizing desalination plants.
2022 Case Studies		
Chemical Plants & Environmental Injustice Based partly on "New EPA Rules Aim to Reduce Toxic Emissions. But Many 'Cancer Alley' Chemical Plants Won't Have to Change" [56]	Locations across the country like Louisiana's cancer alley demonstrate the disproportionate impact that industrial pollution has had on surrounding communities. The communities that most chemical plants are placed in are typically POC and/or poor.	Topics/applications: industrial pollution control, hazardous material process design and handling
Outsourcing Pollution Based partly on "Geographic concentration of pharmaceutical	The US and Europe outsources about 60% of pharmaceutical manufacturing. Hyderabad, India is a hub for drug manufacturing. These plants pollute groundwater and waterways, often harming aquatic fish and contaminating local produce.	Topics: sustainability engineering, biomanufacturing, antimicrobial resistance, outsourced emissions Applications: energy and material efficient process

manufacturing: USP Medicine Supply Map analysis" [57]	Residents are forced to purchase water from alternative sources due to toxic foam/froth (toxic solvents and heavy metals).	design; optimization of process sustainability
Metal Extraction Based partly on "The Dark Side of Congo's Cobalt Rush" [58]	The extraction and production of metal has a history of long-lasting negative environmental and social impacts on the local community. Processing of metal resources often releases pollutants into air, water, and soil, depriving access to safe, local resources, while mining companies and banks profit. The issues faced by local communities for lithium mining in Nevada and Bolivia, and cobalt mining in Ghana and the Congo highlight the need for sustainable and equitable metal extraction.	Topics: metal recycling technology, metal extraction research, Applications: selection of process materials, Metal waste disposal, reuse, or recycling, batteries
Racism in Medical Research Based partly on "'You've got bad blood': The horrors of the Tuskegee syphilis experiment" [59]	The Tuskegee Syphilis study recruited hundreds of African American men from 1932 to 1971, to assess the disease progression of syphilis. During the study, medical professionals intentionally deceived participants on their disease status and the study's true purpose, leading to major health complications and death for the participants. The fallout from the study and other instances of medical malpractice have eroded African Americans' and other groups' trust in the medical community, compounding existing racial health disparities.	Topics/applications: Point-of-use medical diagnostic tools, genetic testing, genetic sequencing, clinical trials

Workshop participant groups were designed with power dynamics and safe spaces in mind and further supported by workshop facilitators

Due to potential power dynamics and sensitive topics in case studies, we carefully curated breakout room groups. Each group had a balanced representation of gender identities; for example, no group had a sole woman participant. There was also a mix of graduate students, postdoctoral fellows, and faculty in each group, with a total of five to seven participants per group. Most groups were made to only have one faculty member, if possible, to minimize the power dynamics at play. Participants were also paired with case studies outside of their research area to minimize preconceived bias. The organizing committee reviewed the groups beforehand as well to ensure that no known personal conflicts were present.

Facilitators for breakout rooms were assigned to promote a meaningful breakout room discussion. In 2020, four facilitators rotated around three or four rooms each. However, after feedback indicated a need for further guided discussion, the workshops in 2021 and 2022 had one facilitator assigned to each breakout room. Each facilitator's role was to encourage participation from all group members and guide the group through the case study. Part of this involved keeping track of time and ensuring that the time limits on each section were met. Facilitators were also responsible for addressing any conflicts. They were able to alert all facilitators and the organizing committee to any conflicts proving difficult to resolve to get support from another person. To aid in this aspect, an anonymous form was available for all participants during the workshop to alert organizers of any immediate conflicts. Notably, all responses in the form to date have been unrelated to any conflicts, but instead related to minor questions and comments. In case of extreme conflict, participants could be moved to the main room to discuss and resolve any issues with a facilitator before returning to their room, which is not a method that has ever been needed used thus far. All facilitators were required to attend a training session about a week before the workshop to learn their duties and ask any questions.

A post-workshop survey provided guiding feedback

The results of the survey administered to participants and facilitators are discussed in the next section. The survey was distributed via email several times to maximize response rate. All survey answers were anonymous and decoupled from demographic data prior to analysis. Survey questions included department role demographics, experience with each workshop component, self-assessment of gains from the workshop, and interest in future events. Additionally, the survey included qualitative questions that asked the following:

- What was the most helpful part of the workshop? What was done well? (n=88/102 survey participants, 86%)
- What was the most confusing part of the workshop? What do you wish had been done differently? (n=80/102 survey participants, 78%)
- What do you want to know more about? (n=48/102, 47%; not analyzed in this study)
- What is one action item you could take be anti-racist in your research? (Responses to this question will be shared publicly, but anonymously). (Note: only 2021 and 2022 workshop; n=4/48, 8.3%; not analyzed in this study).

For this study, we focused on analyzing the first two questions. We coded responses to the first question by workshop component aligning with the quantitative data categories and coded responses to the second question by theme of feedback (such as workshop component or facilitation), noting that some respondents listed multiple components. Feedback from each year was also used to guide small changes in subsequent years. We also note that the last question was only asked in the 2021 and 2022 workshop years, as in the 2020 year, there was an additional Part 2 of the workshop where this topic was the focus and asked this question during the session. This study was reviewed by the Institutional Review Board (IRB) and was deemed "not human subjects" research due to the way the anonymous data was collected.

RESULTS

Workshop participants represented mostly graduate students, but survey respondents came from all case studies

While graduate students, faculty, postdoctoral fellows, and staff were invited to attend the workshop each year, graduate students consistently made up the majority of the participants and survey respondents, and thus responses will primarily be indicative of the graduate student experience and value gained from the workshop (Fig. 1A). Faculty participation began at a relatively high fraction of total department core faculty in 2020, but declined over the years. Some of this decline can be attributed to a subset of faculty—those involved in the ARDEI Committee—serving as workshop facilitators in 2021/2022, where facilitator survey responses were excluded from the analysis (6 total facilitators, 3 were faculty). However, the majority of the decline represents a source of future interest and improvement, as faculty involvement in the workshop is critical in supporting their own understanding of connecting research to social justice, conveying the importance of this topic given their positions of power in the department, and propagating a practice of socially just research from the top down.

Survey results also indicated an even spread of responses from participants across the different case studies (Fig. 1B). Thus, our results and conclusions about participant experience and gain from the workshop will be representative of the workshop and independent of specific case studies. Further, the case studies were designed to be held in parallel, and we assume they are of comparable quality in terms of content and provided the same benefits to participants.

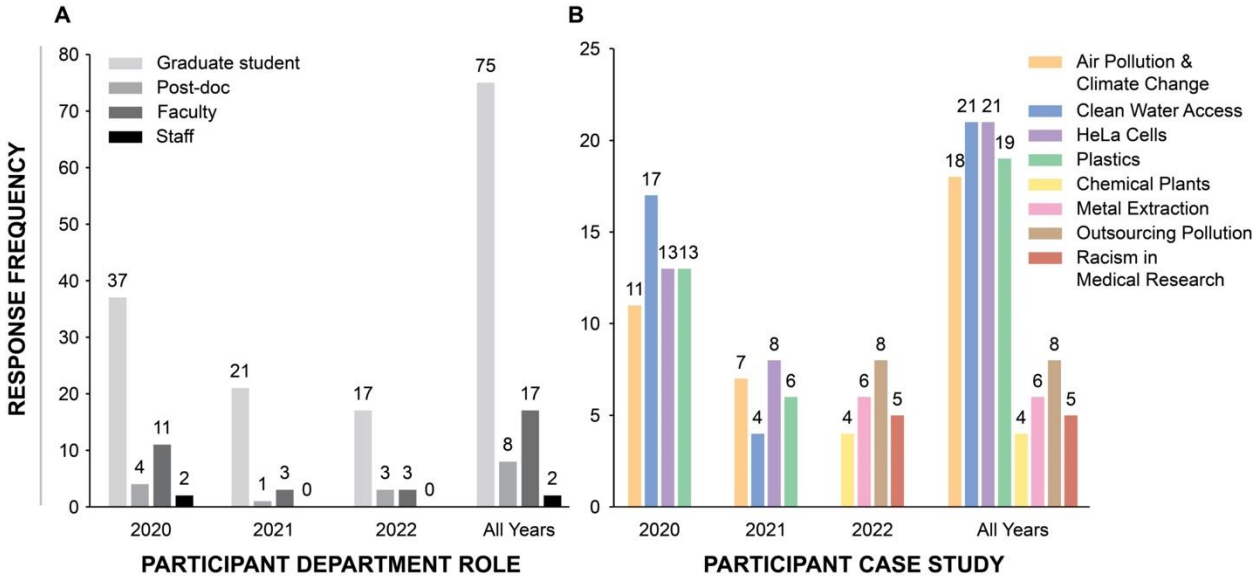

Figure 1. Workshop participant demographics across all years. A) Number of workshop survey participants in each department role (graduate student, post-doctoral researcher, faculty, or staff) in each year and summed across all years. **B)** Number of workshop survey participants in each case study offered in each year and summed across all years.

Workshop components generally proved effective and useful in supporting participant learning

Each year, we asked participants to rank each component of the workshop on a 4-point Likert scale with 1 representing "very uninformative/unhelpful" and 4 representing "very informative/ helpful" with an additional "not sure" option. Given the different number of participants in each year of the workshop, we show the data summed across all years and represented as percentages for ease of assessing and ranking value of workshop components (Fig. 2). We also analyzed the qualitative analysis of the survey questions asking what the most helpful and most confusing parts of the workshop were to gain deeper understanding of our quantitative results.

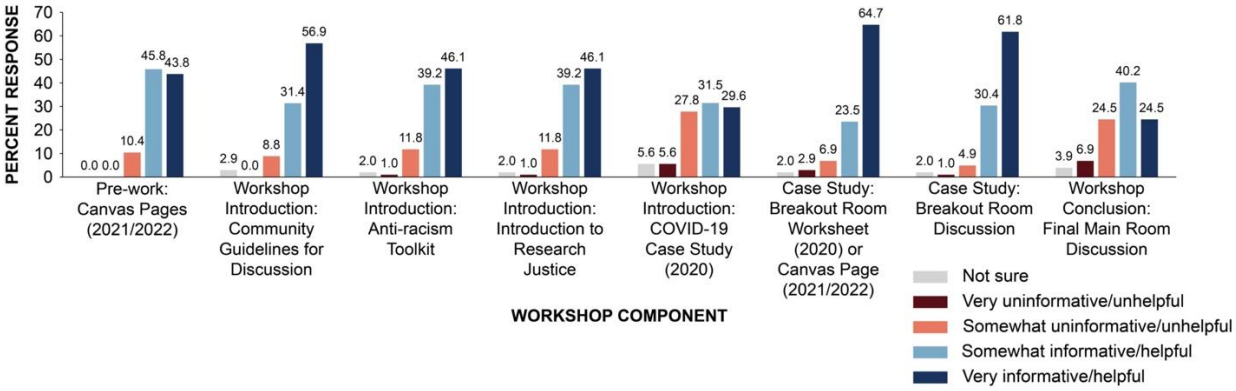

Figure 2. Overall informativeness/helpfulness of each workshop structural component. Data represents percent of total responses (2020-2022) in each category on a 4-point Likert scale (1-Very uninformative/unhelpful, 4-Very informative/helpful) with a "not sure" option for each workshop structural component.

Case study pre-work and workshop introduction components helped set up the success of the case study component of the workshop

The case study pre-work and workshop introduction components—including the community guidelines for discussion, anti-racism toolkit, and introduction to research justice—were rated almost entirely as "informative/helpful" or "very informative/helpful" by participants. These components laid the groundwork to ensure all participants had the necessary background, common language, and modes of engagement for participating in the subsequent case study breakout rooms, where topics would become more specific to the case, and participants would be engaging directly with one another. We hoped that this shared foundation, along with the community guidelines, would foster respectful, safe conversation on these challenging topics. In support of our findings, one survey participant noted in the qualitative survey responses that the most helpful part of the workshop was "*making a safe space and preparing participants that it's ok to be uncomfortable*." We believe this is key to successful workshop outcomes and that our pre-work and workshop introduction components supported this goal.

The COVID-19 case study was cut due to lack of value to participants

In 2020, we presented a COVID-19 case study preceding the small group breakout room discussions to serve as an example and model of how to understand a problem through a social justice lens. However, participants rated this the least useful workshop component in 2020 in both the quantitative, shown in Fig. 2, and the qualitative data, where 11/70 (15.7%) responses to the survey question about which workshop component could have been done differently related to the COVID-19 case study. Thus, in subsequent years it was cut from the workshop due to lack of value in favor of spending more time in the breakout rooms. This is one example of how the workshop was adapted, based on participant feedback, to improve the participants' experience and time-investment.

Case study materials and the discussions they fostered were rated most useful by participants

The most valuable component of the workshop was the case study, in particular the case study documents (presented via worksheet in 2020 and Canvas pages in 2021/2022) and the breakout room discussion, which was guided by questions within the case study documents and supported by workshop facilitators as needed. This quantitative finding was supported by the qualitative analysis on the survey question that asked "what was the most helpful part of the workshop? What was done well?". Of the 88 total responses, 47 responses indicated that the case study was the most helpful/well-done aspect of the workshop and 33 responses indicated that the breakout room discussion was the most helpful/well-done aspect of the workshop. In support of the case study worksheets, participants noted that "*The worksheets prepped by the organizers were REALLY well done! I felt that these facilitated discussions easily and were also informative*", "*I really appreciated all of the linked resources and articles. These provided good background and context to the discussions in addition to explaining new topics and providing new information*", and "*the case studies were also structured very well and allowed for people from all backgrounds to respond and reflect on their own experiences*." These highlight how both case study structure and content facilitated learning. In support of the breakout room discussions, one participant noted that "*The break out groups and discussions were the most helpful as the worksheet was well designed and fostered conversation. Conversation is key for addressing these topics.*" Similarly, one noted that it as most useful to "*be able to hear my colleagues thoughts on the intersection of scientific research and social injustice*" while another stated that "*I think my group discussion was extremely powerful"*. These quotes highlight the importance of the interactive, open discussion-based nature of the workshop in facilitating learning.

We asked participants what about the workshop was most confusing or that participants wished would have been done differently and categorized comments by theme, where some participants commented on multiple themes, which resulted in more comments than total participants despite some not responding to the question at all. The theme with the most comments on areas of improvement provided (37/109, 34%) related to work aspects of workshop facilitation, such as time management (particularly in the breakout rooms) and indicating a need for more guidance

or facilitators in the breakout room (which were added after 2020). We believe adding the breakout room facilitators helped, and we continue to address these comments.

Overall, these findings also confirm the assumption that independent of the specific case study participated in, participants found the case studies were valuable in assisting their learning. We attribute this high-value ranking to the specific nature of the case studies and their direct connection to chemical engineering topics, where the majority of participants (graduate students, post-docs, and faculty) are conducting research in related areas. These case studies provided concrete examples of analyses of research topics with social justice in mind, ideally giving participants a framework for similarly analyzing their own research. Additionally, by placing participants in case studies with topic areas distinct from that of their research, we aimed to eliminate any preconceived notions about the topic, minimize thoughts of personal relationship or guilt during the workshop, and maximize the value to participants. We note that a few participants (6/102, 6%) indicated that they would have preferred to be in case studies related to their own research, with three noting their lack of background made it harder to participate, three noting it would have made the workshop more directly applicable or actionable to their own work, and one not giving a reason (where one participant noted two reasons). However, based on the data, we believe our case study assignment strategy was effective at minimizing bias and still promoting learning—though we cannot conclusively prove it was because of how participants were placed into case studies.

The workshop conclusion may require changes to provide more value

The workshop conclusion—which takes place in the form of a group discussion by bringing everybody out of their breakout rooms and asking representatives from each group to share collective thoughts, reflections, and learnings from the case studies—has been the weakest part of the workshop across the three years we have run it, which was also reflected in many of the qualitative responses. From the qualitative responses to the question about what could have been done differently, 14/109 (12.8%) total comments noted the main room discussion was not particularly effective. For example, in the 2020 one participant indicated that "*It might have helped to have a more specific question that each breakout room was supposed to report back on -- something with a short answer, given the number of rooms*", while one from 2021 indicated that "*The final discussion was rushed a bit hard to remain engaged in. I think having the facilitators gather a 2-3 sentence summary to display on the screen would provide good feedback in a more organized group."* We attempted to use the feedback provided to make changes each year to this workshop component. We believe these changes improved the component somewhat, as indicated by a workshop participant in 2022 that stated "*I liked that the responses from each group at the end were shorter, but I felt like I didn't get context about some of the case studies from it. Still, two sentences is much better than paragraphs from everyone!*", which was the only feedback about the main room discussion that year. However, there is still room for improvement. While it is not rated as entirely uninformative/unhelpful, we believe that the various attempted structures for the main room discussion fail to provide participants with any substantive gains from groups outside their own. These discussions were brief and high-level due

to time constraints. Additionally, people may become mentally exhausted after participating in the breakout rooms where topics are more sensitive and engagement levels are higher. This aspect of the workshop likely requires some refinement in order to find a useful way to conclude the workshop.

The workshop is effective at both promoting research justice and setting the stage for future conversations or events surrounding topics of social justice

The goal of the workshop was to expose participants to the ideas of research justice and help participants feel more prepared to think about the impacts of their research on Black, Indigenous, and People of Color (BIPOC) communities. Additionally, as this was an early initiative in directly engaging with and discussing ARDEI topics in our department, we also used this as a litmus test for understanding whether participants, and thus department members, wanted more opportunities for this type of engagement in the future.

Participants leave the workshop more prepared to engage in research justice going forward

When asked directly if participants felt that they walked away feeling more prepared to think about the impact of their research on BIPOC communities, the majority each year and 74.5% across all years indicated that they did (Fig. 3A). This indicates the success of the workshop in accomplishing its designed objective, and again confirms that participants experience this benefit regardless of both department role and specific case study they engaged with.

Participants desire future department events surrounding direct engagement with ARDEI topics

In 2020, there was significant hesitancy and fear surrounding discussing ARDEI topics as a department given the politicization of these topics and fear of causing harm to minority identity holding individuals. However, we sought to prove that these conversations were not only necessary and important, but desired by the community. When directly asked, the majority of participants (89.2% across all years) indicated that they wanted to see more departmental events like this workshop in the future (Fig. 3B). This provided the proof needed to catalyze the creation of our department's ARDEI Committee and their subsequent initiatives. We also believe this can provide hope to other departments that students actively want to engage with these topics, and departments can ideally remove this as a possible barrier inhibiting taking these actions.

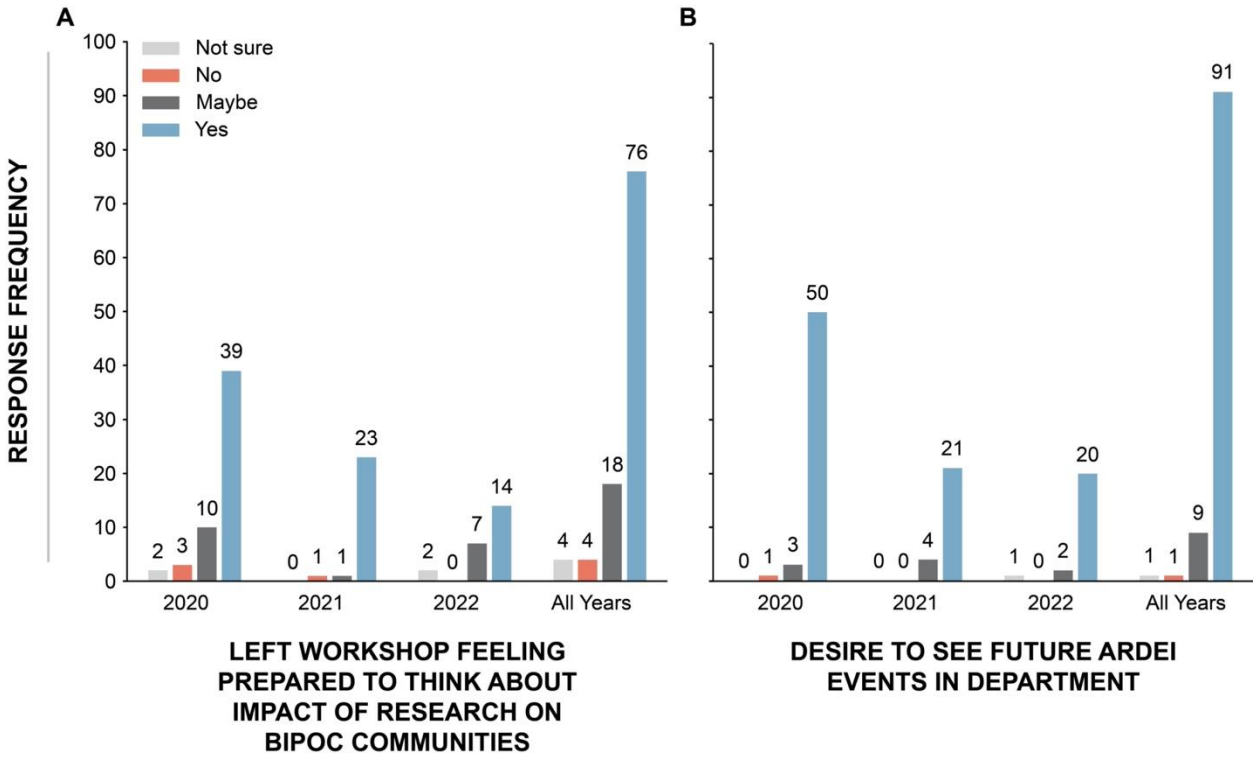

Figure 3. Participant workshop takeaways and desire for future ARDEI events. Number of participants each year and summed across all years who indicated **A)** degree to which they walked away from the workshop feeling prepared to think about the impact of their research on BIPOC communities and **B)** the degree to which they desire to see future ARDEI events in the department.

Workshop benefit and desire to see future ARDEI events in the future is independent of prior workshop attendance

We also asked participants how the workshop compared to the previous year, if they attended. While many participants are new—likely given the coincidence of the workshop with department retreat and incoming cohort of new graduate students—repeat participants indicated the workshop quality either remained about the same or improved (Fig. 4). These data, combined with that of Fig. 3, indicate that the intended and participant reported workshop benefit can simply be gained by engaging with a different case study (in the case of repeat participants) and by those who are likely incoming graduate students who do not yet have a specific research project (in the case of new participants).

Figure 4. Relative workshop quality over time. Number of participants who indicated how the workshop quality changed relative to the year prior or who did not attend the workshop the year prior.

DISCUSSION/CONCLUSION

The repeatability and sustainability of the workshop are crucial for its continued success

Due to the transient nature of those in graduate school, it is necessary to engage in conversations related to ARDEI regularly to introduce new department members to the concepts and to encourage such conversations as regular practice. Therefore, we hold the workshop annually during the week of our annual departmental retreat. This is effective as it starts off the new academic year with important conversations and is during a week of department socialization. It is also noteworthy that the development of the case studies requires sufficient time and effort to be of appropriate quality. Therefore, we recycle case studies for two years before constructing new ones. All studies are checked beforehand to ensure that all information is relevant, potential for causing additional harm to those holding historically marginalized identities is minimized, and all technical aspects, such as links provided, are in working condition. Thus far, we use four cases studies per year, which allows for a spread of topics and enough variability for our department size.

The ultimate goal is for participants to consider learned concepts in their own research

The workshop introduces ARDEI concepts and aids department members in having a similar vocabulary when discussing such ideas. It also works to remove the stigma of discussing topics that are often considered uncomfortable in academia. Allowing participants to consider social

justice concepts in the context of chemical engineering topics unrelated to their research reduces the chance of preconceived bias; however, the goal is ultimately to promote the consideration of these intersections in a participant's own research. In 2020, we held a second part of the workshop to guide participants through questions related to research justice in the context of their own research using materials sourced from Free Radicals [21], [32]. Participants worked with those in their research groups or in similar areas of research to assess the questions presented to them in the introduction of the first part of the workshop. We then asked participants to share one action they planned to take following the workshop.

Due to the time needed to go through the workshop, we no longer offer the second part. However, this has perhaps led to a decrease in the direct application of concepts to participants' research. One possible route for an altered, and ideally more fruitful, workshop conclusion and transition for participants from simply learning to taking action toward research justice would be to alter the workshop conclusion to fit this purpose. This conclusion would begin with a short presentation on how the framework used in these case studies can be directly applied to and used in the day-to-day research of the participant. This presentation would then be followed by an active-learning style activity wherein we ask participants to reflect on their own research, draft an action item or take away they can apply to their own research, and to reconvene in their small groups for a brief discussion/sharing of ideas. Then, we will encourage labs to go through the entire exercise as a group shortly after completion of the workshop.

We believe this would provide a better use of their time and a more direct connection of the framework used in the case studies to that of their own research, which we had in 2020 in the form of a follow up workshop but did not have directly in 2021 and 2022. This lack of asking participants to directly connect the learned framework to their own research and daily lives is a current point of improvement for the workshop. In addition to the few participants who noted that they would have preferred to be in case studies related to their research, a few participants (6/102, 6%) indicated that they wished they could have walked away with new ideas for action or more concrete steps to take in their own research. With a guided method to move from thinking about social justice concepts in the context of research unrelated to one's own work, we hope to make these considerations a natural part of the research process for all members of the department.

We encourage use and adaptation of this successful workshop across institutions

The workshop in its current form serves as a springboard for other related discussions and actions in the future. Given the success of the workshop and the participants' overwhelming desire for more like this, which we believe is representative of engineering populations across many institutions, we strongly encourage those at other institutions to utilize the materials and evidence of success presented here to host this or a similar workshop in their own departments. All materials will be provided freely, and while case studies were centered on topical areas related to chemical engineering in our department, they could easily be used directly, adapted, extended, or serve as the bases for case studies in other departments.

AUTHOR CONTRIBUTIONS

KC, ANP, JMC, and CER conceived of the idea for the workshop, created the 2020-2021 case studies, hosted the workshop in 2020 and 2021, and managed data collection for those years. KC, WB, RL, MO, SLR, DRV created the case studies for the workshop in 2022, hosted the workshop in 2022, and managed data collection for that year. JLC served as a workshop participant in 2020 and workshop facilitator in 2021 and 2022. KC, ANP, and JLC designed and conducted the study, applied for IRB approval, analyzed and interpreted results, and drafted the manuscript. JDG contributed to drafting of the manuscript and qualitative data analysis. WB, JMC, RL, MO, SLR, CER, and DRV provided feedback on the manuscript.

KC and ANP are co-first authors of this paper. WB, JMC, JDG, RL, MO, SLR, CER, and DRV are co-second authors. JLC is the corresponding author.

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