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Teaching Social Justice to Engineering Students

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Abstract
In this paper, we describe the design and implementation of a novel course called "Science and Engineering for Social Justice" that explores social justice in a science and engineering context, with specific focus on race, gender, sexuality, and disability. We emphasize what students can do to advocate for and represent diverse peoples, and to promote social justice through science and engineering practice.

Although applicable to all engineering majors, our work is particularly relevant to educators in biomedical engineering (BME), as the course is focused on several interdisciplinary topics in BME such as universal design, CRISPR genome editing, DNA forensics, sustainable technology, and pharmaceutical and vaccine development.

In this paper, our aim is to make teaching about social justice issues more manageable for engineering educators. We provide instructor observations, and analysis of student impact, and full curricular materials including assigned readings, lecture slides, and assignment descriptions online [link blinded for peer review]. The curricular materials and insights from this paper are interdisciplinary and transferable to many courses in BME and related fields.

In order to make our curriculum more accessible to engineering educators who do not have backgrounds in critical theory (and because we are not experts in these fields ourselves), in this paper we do not provide an extensive background of critical theories on race, gender, sexuality, or disability. However, we do recommend the following resources: Donna Riley's book, Engineering and Social Justice [1], The Center for Critical Race and Digital Theories [2], "Critical Race Theory: An Introduction" [3], and Langdon Winner's "Do Artifacts Have Politics?" [4]. As we developed "Science and Engineering for Social Justice," these resources have been particularly helpful: books [see 1, 6, 7], websites [see 8-11], and articles selected for the course (see below).

Teaching Social Justice in the Context of Engineering

Social justice-themed courses are not found in most engineering curricula. As stated by Lord and colleagues in a recent paper describing their efforts to create "Changemaking Engineers" through the Engineering Exchange for Social Justice (ExSJ) at the University of San Diego School of Engineering: *"…engineering students are trained technically, with less focus on critical examinations of assumptions within engineering practice, and less emphasis on the larger contexts in which engineering is embedded"* [5].

Finally, although our course is not a technical engineering course, recent examples of engineering courses from Jon Leydens and colleagues have informed our implementation of "Science and Engineering for Social Justice." In a control systems engineering course, students demonstrated that they have some awareness of social justice in general, but typically struggle to connect social justice concepts to the technical content of their core

courses [12]. In a study involving three courses at different universities, instructors identified principles of design for social justice and examples of to implement those principles in design courses [13].

Science and Engineering for Social Justice: Course Description

In this course, students critically evaluate how cultural and scientific theories of race, gender, sexuality, and disability influence one another. In other words, how the "anatomy of difference," or visible physical differences among people, has been used historically and in current times as evidence that certain people should be treated differently not only in society, but also in terms of access to technology, healthcare, and research [14].

Throughout the course, we discuss how racism and sexism manifest in engineering solutions, such as in the development of machine learning and artificial intelligence tools that are used in facial recognition software; sentencing in the criminal justice system; determining emergency response protocols; and how to diagnose, treat, and medicate patients [15-17]. For an overview of ethical principles involved in machine learning and artificial intelligence, please see [18].

In another example, we look at how the lack of representation of women in pharmaceutical trials is actually based on the traditional view that women should be protected and that all women of childbearing age will likely be pregnant multiple times, thus making them research subjects [19]. For an overview of feminist theory in the context of engineering education, see [20].

Background and Motivation for Course Development

We have previously published work describing a pilot effort (on-week module) where we introduced the interplay of engineering ethics and DEI (diversity, equity, and inclusion) in a large introductory bioengineering course [21-22]. Our rationale was that students will readily accept that engineers have a code of ethics, but may not have made the connection that DEI is an ethical issue, and that any ethical practice includes DEI. These early efforts were intended to serve as model curricula to be implemented in an existing course.

Recently, we described the launch of "Science and Engineering for Social Justice," a 5-credit, writing-intensive, discussion-based course [23]. In the first three offerings, the course had had an enrollment of approximately 30-35 students from both STEM and non-STEM majors. In this paper, we describe the fully developed curriculum, instructor insights, and student impact over the first three offerings of the course in 2018-2020.

"Science and Engineering for Social Justice" has been developed over the past four years by one faculty member, two students who were undergraduate Bioengineering majors and honors students at the time, and one graduate student who holds an undergraduate degree in engineering, a master's degree in education, and is currently pursuing a PhD in human-centered design and engineering. We were motivated to create this course for several reasons. As individuals, we are passionate about social justice. We are members of underrepresented groups in STEM, and thus we are committed to increasing engagement of underrepresented students in science and engineering.

In addition, we hoped that the social justice theme would be appealing to underrepresented students, who are more likely to make educational and career choices based on opportunities for service to their communities [24]. Finally, although ethics and diversity are critical components of engineering training and practice, most undergraduate engineering programs do not address these issues in-depth [25-26].

We launched "Science and Engineering for Social Justice" as a 5-credit course selected in a competitive process through the University Honors Program. We chose to offer the course through the honors program to reach a diverse audience of students who were accustomed to high-level engagement with course material.

By offering the course through the honors program was that we wanted the class to be composed of both STEM and non-STEM students to cultivate a more rich dialogue among students with different interests and strengths. Although we did not collect demographic data on students, as instructors we observed that in each offering of the course, at least 75% of the students were women. In addition, most of the students who self-identified as underrepresented minorities in class discussions or assignments were not engineering majors. Thus, we strongly believe that a course on social justice issues in engineering should not be limited to engineering students only.

The small course size (n=30-35 students) for honors courses is appealing, as our curriculum is discussion-based and requires a degree of trust among students because many topics can bring up intense emotions and may be triggering. In addition, the two undergraduate student developers of this curriculum participated in the honors program, so they were familiar with the rigors and expectations of honors coursework. Finally, the honors program awards funding for a student teaching assistant for each course selected through the competitive process.

Course Topics and Themes

Throughout the course, students are asked to reflect on who gets to be a scientist or engineer, who defines which questions researchers ask and which problems engineers solve, who benefits from these solutions, and what role social justice plays in science and engineering practice.

Through a social justice lens, we explore the ethical implications involved in how technologies impact underrepresented people with specific focus on race, gender, sexuality, and disability. Topics include:

1. Current innovations and emerging technologies, such as: artificial intelligence, CRISPR genome editing, and DNA forensics;
2. Processes involved in a variety of engineering disciplines, such as: sustainable technology, energy production and storage, hazardous waste disposal, and pharmaceutical and vaccine development;
3. Interdisciplinary methodologies to work towards eliminating inequities, bias, and barriers, such as: inclusive design (e.g., curb cuts to allow wheelchair access on sidewalks and representative standards in transit, automotive, airline, and medical

contexts); and increasing access to healthcare, technology, participation in government and elections, and infrastructure (clean water, energy, sanitation, and transportation).

Throughout the course, we explore these inter-related questions:

1. How do our cultural ideas about race, gender, sexuality, and disability influence science and engineering knowledge and practice?
2. On the other hand, how does our science and engineering practice influence our cultural ideas about race, gender, sexuality, and disability?
3. How can we use science and engineering to promote social justice for all people?

Students reflect on the impact of science and engineering in society through weekly readings, written reflections, class discussions, and in-class debates. In addition, students complete an individual final paper and a team project in which they design a scientific or engineering solution that promotes social justice.

Learning Objectives

We explore social justice in a science and engineering context, with a focus on DEI (diversity, equity, and inclusion). We discover why scientists and engineers must practice inclusive design and think broadly about the impact of their work on diverse populations, including ethical implications, potential inequities in access, and bias against underrepresented people.

By the end of the course, students should be able to:

1. Identify how cultural concepts of race, gender, sexuality, and disability have shaped scientific thought and engineering practice (and vice versa) through history.
2. Conduct self-directed inquiry to identify, critically evaluate, and cite relevant literature.
3. Critically analyze the social and political context of scientific and engineering technologies.
4. Apply ethical analysis and creative problem solving techniques to design solutions for diverse user groups.
5. Propose approaches to promote social justice in science and engineering practice.
6. Critically evaluate claims about the science of human difference and reflect on how these scientific theories have been used to promote or fight inequality.
7. Work effectively in teams.
8. Develop technical communication skills in oral and written formats.
9. Evaluate the positive and negative impacts of science, engineering and technology on marginalized groups.
10. Identify how scientists and engineers handle implicit bias during research and design processes.
11. Recognize social justice issues in their community and field of study, and feel empowered to affect change.

Curriculum: Course Topics and Assignments

Students are introduced to topics in social justice through lectures, assigned readings, documentaries, and guest speakers (Table I). The 5-credit course satisfies Honors requirements and also fulfills Writing and Diversity credits, which are graduation requirements for all students from [university name]. The class meets for two 110-minute sessions per week.

The course topics are outlined in Table I. We begin with a few examples of bias in scientific narratives, such as the story of fertilization where the sperm and egg are (inaccurately) assigned traditional gender roles. The egg is depicted as lethargic, passive, and simply waiting to be "penetrated" by the vivacious, motivated sperm [27].

Table I. Overview of Curriculum

Week	Topics and Class Activities
1	Introduction + Classroom expectations What does social justice look like?
2	Implicit Bias Representation: Who Identifies as a Scientist or Engineer? History of Sex/Gender and Sexuality in Science and Engineering
3	History of Disability in Science and Engineering Disability and the Justification of Inequality
4	Introduction to Universal Design Design for People with Disabilities Documentary: "Fixed"
5	Debate: Should we "fix" people or environments? Topic Pitches (individual)
6	History of Race in Science and Engineering Design for Low Resource Settings
7	Scientific Approaches and Engineering Solutions for Contemporary Issues in Social Justice (Guest speakers) Documentary: "I Am Evidence"
8	Introduction to Bioethics Improving Access to Healthcare Genome Editing, Gene Patenting, and Genetic Data
9	Debate: How should genetic data should be shared?
10	In-class Peer Review Team Project Presentations

We discuss the medical and social models of disability, and how perceptions of disability have introduced bias into research and design for people with disabilities. For example, we examine the development of exoskeletons and how exoskeletons may or may not meet the needs of people with disabilities [28]. We further examine disability research, transhumanism, and perspectives of people with disabilities through the documentary "Fixed: The Science/Fiction of Human Enhancement" [29].

We discuss scientific theories that have been used to justify bias such as research on physiological differences associated with gender, race, and sexual orientation. For example, we discuss recent findings that 33% of current medical students believe that the nerve endings of Black people are "different" from those of non-Black people, which may be linked to disparities in pain management prescribed by doctors [30]. In addition, medical equipment such as spirometers until recently were calibrated differently for Black people [31]. For a recent review that identified interventions to reduce and ultimately eliminate racial inequities in health, please see [32].

Students explore these topics in-depth through in-class discussions and debates, written reflections, team project, and an individual topic paper. Brief descriptions of these assignments and their weight in the final course grade are provided in Table II.

Table II. Description of Assignments

Weekly Written Reflections (30% course grade)	You will be expected to reflect on course readings, lectures, and/or your own experiences to prepare for in-class discussion and activities. (1–2 pages, single-spaced)
Engagement in Class Activities (20% course grade)	In our class meetings, we will combine our diverse perspectives, experiences and academic backgrounds to better understand the week's topics. As such, we strongly value respectful, thoughtful in-class engagement. This entails coming to class ready for the week's discussion and sharing your responses to the reading, discussion questions and classmates' opinions.
Team Project (20% course grade)	In a team of 3-4 students. you will select a social justice topic that involves an issue or problem in science or engineering, and then propose an ethical solution that promotes diversity, equity, and inclusion. This team project builds upon all the activities and knowledge gained throughout the course, and will include a short written proposal and a team presentation.
Topic Paper (40% course grade)	For this course's final, you will draw on the course concepts in order to write a 6–8 page (double-spaced) analysis of any social justice topic in science or engineering. You may choose from the topics provided or propose an original topic.

One major assignment for the course is the team project, where students are asked to identify a social justice topic that involves an issue or problem in science or engineering, and then propose an ethical solution that promotes diversity, equity, and inclusion. Examples of team project topics from all three offerings are shown in Table III.

Table III. Example Team Project Topics

- Creating Diversity in STEM Education Standards
- The Role of Technology & Engineering Design in Voter Suppression
- Addressing College Student Mental Health
- National Voting + Election Day Holiday
- Racial Disparities in Healthcare
- Social Justice and Pain Management
- Blockchain Voting System for Equal Access
- Inspiring youth in foster care to pursue STEM
- Improving accessibility of menstrual products for homeless women
- Improving access to healthy food for people in low-resource areas
- Portal to connect homeless people with local resources
- Effects of prolonged screen time on children from high- and low-income families

As the culminating assignment for the course, the individual topic paper is broken down into several assignments. First, the students write a short topic proposal that the instructor approves. Then, the student gives a brief "pitch" to the class about their intended topic, with the aim of receiving feedback on the interest level of the project, scope of the project, and any additional resources that other students may suggest. Immediately following the pitch, each student writes a short written reflection about how peer and instructor feedback may have modified the focus or scope of their project, or helped the student identify additional resources.

With their final paper topic fully vetted and scoped, each student writes an annotated bibliography and 6-8 page rough draft, which is peer reviewed in class and commented on by the instructor. Each student writes a reflection on how they will edit their draft due to feedback they received in peer review or how they were inspired to do something differently by reading another student's draft. The final draft is due at the end of the quarter. See selected topics for final papers in Table IV.

Table IV. Select Examples of Final Paper Topics

- Creating Diversity in STEM Education Standards
- The Role of Technology & Engineering Design in Voter Suppression
- Addressing College Student Mental Health
- National Voting + Election Day Holiday
- Racial Disparities in Healthcare
- Social Justice and Pain Management
- Blockchain Voting System for Equal Access
- Gender gap in portrayal of women in gaming
- Cross-cultural medical ethics in female genital cutting
- Stigma and social impact of AIDS
- Designing artificial intelligence without bias
- Role of scientific bias in genocide
- Racial bias in facial recognition systems and impact on law enforcement
- Ethics and societal impact of prenatal genetic testing
- Racial inequality in public transportation
- Inequity in stem cell therapy research
- Promoting use of electric vehicles in low-income populations
- History of disproportionate use of lobotomies in underrepresented patients
- Promoting social justice in conservation biology

Creating an Inclusive and Safe Classroom Environment:
As this course is discussion-based, one of our primary concerns was creating an inclusive classroom environment where all students feel safe and respected while sharing their viewpoints. To promote a sense of community, students had paper name cards including their preferred name and pronouns (e.g., she/her; he/him; they/them). This helped the instructors learn student names, and allowed students to address each other more easily in group discussions, and facilitated formation of small groups for class activities.

We recognize that many topics in social justice may elicit strong emotions or possibly trigger students, and that students have diverse perspectives. To promote honest and respectful discussions in class, we established the following class expectations based on student feedback obtained from a pre-course survey and in-class discussion.

To create a safe space to explore sensitive topics:

1. Respect everyone!
2. Instructor will provide a list of topics before class. Students have the option to leave the room or complete an alternate assignment, no questions asked.
3. Recognize everyone is here to grow and learn. It's okay if you don't know the right words or have the "correct" answer.
4. Ask student how they would like us to support them, rather than imposing unwanted advice.

5. Individuals in this class are held accountable for their actions only.
6. No individual person in this class will be held accountable or attacked for the behavior of a group they identify with.
7. Underrepresentation or oppression of a specific group does not mean that students of other groups are to blame or do not have the right to a viewpoint.

To help students feel prepared and comfortable sharing their thoughts with the class:

1. Structure activities so students can process topics individually before discussing in group/class.
2. No calling on students; only volunteers who raise their hands.
3. Discuss prompts in small groups before sharing with class.

To maintain confidentiality, students agreed not to share any identifying student information outside of class. For example, it is acceptable to tell a friend "In one of my classes, I've been thinking a lot about the impact of racial discrimination." It is not acceptable to share another student's specific experience with discrimination, or any personal identifying information.

In addition, the syllabus contains the following statement on Diversity and Inclusion:

"Our teaching team strives to provide an inclusive learning environment in which all students feel safe and respected. We appreciate diversity and respect each student's individuality. We welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, identities, national origins, religious affiliations, sexual orientations, ability, and other visible and nonvisible differences.

Students should know:

1) *Every student will be treated with respect and fairness by the teaching team.*
2) *In return, students are expected to treat their classmates and the teaching team with respect at all times.*
3) *Any student who has suggestions or concerns about inclusivity should talk to [faculty]. Your feedback and suggestions are welcome!"*

Course Assessment

Instructor observations and student feedback were overwhelmingly positive. We would like to emphasize that this is in large part due to the high level of interest in social justice and our efforts to create an inclusive and safe classroom environment, as discussed in detail above.

At the end of each course offering, we evaluated the impact of the course through examination of student self-reported data about their perceived ability to identify and approach social justice issues in science and engineering.

In addition, at the end of the course students were asked to reflect on what they learned that they can use in the future. Many students reported gaining confidence in their ability to communicate about social justice and apply their knowledge to future research or

design projects. A number of students indicated the course helped them learn to advocate for themselves or other people. Excerpts from final reflections are shown in Table V.

Table V. Excerpts from student final reflections (submitted to instructors)
"After this class, I feel like I am looking at the world in terms of how accessible it is for different people with different abilities."
"I'm less apologetic about my interest in issues that directly affect me (feminism and racism/stereotypes…). I shouldn't moderate my interests."
"I think I can be more considerate of social justice issues in future projects [and have an] idea of how to design for disadvantaged communities."
"I enjoyed taking a break from the technical aspects of my other engineering courses to take a higher level look at engineering and how it impacts society."
"This was a very stimulating course in that it raised questions I've never had the opportunity to discuss in an academic setting before."

Many students reported that they had a positive experience in the class due to the quality of in-class discussions. Students noted that the instructor is "good at prompting discussions" and "encourages a wide range of perspectives" during class discussions. Students also had positive feedback on the course organization, noting that they appreciated "spreading assignments across quarter so it isn't one large assignment at the end." Furthermore, several students provided comments when they turned in their assignments online. Two examples are shown in Table VI.

Table VI. Examples of student comments submitted with assignments
"I wanted to say thanks for an awesome quarter and a really friendly class environment. I always felt comfortable sharing my ideas and it was great to learn new things." (submitted with final paper)
"… both articles introduced information that was new to me and I feel that after this class I will have so many new perspectives to think about when it comes to combatting bias and advocating for accessibility through societal change." (submitted with weekly reflection, assigned readings on disability)

Finally, students also enjoyed the "mix of modes and activities during class" such as videos (documentaries and clips from TED talks, etc.), recent research articles, current news articles, and assigned readings.

Over all three offerings, the student comments in student end-of-course evaluations were overwhelmingly positive. Examples of student comments from formal end-of-course evaluations from 2018-2020 are shown in Table VII.

Table VII. Examples of student comments in end-of-course evaluations (administered by university)
"I absolutely loved this class and learned so much, and it gave me a lot of awareness and sensitivity to other people." 2018
"This was a topic that I hadn't explored much before and… I now feel more confident tackling topics of social justice within science and engineering." 2018
"This class was constantly stretching my thinking and making me think outside the box. Each day we talked about topics and questions that had no clear answer and that needed a wide range of people to talk about." 2019
"I was able to think about social justice issues that I hadn't thought about or wasn't even aware about before. I gained insight into the issues that certain marginalized groups face, and I was even able to reflect on my own actions and the consequences of my own biases." 2019
"Amazing class and I'm so glad I took it. I think everyone in STEM should have to take it, I feel like I am a more conscious citizen and that I am more interested in using my STEM degree in the future to help people and make change." 2019
"[This class] made me reconsider my biases and actively think through how my work as an engineer affects people who don't live where I do, don't live life like I do, and don't have the same socioethnic [sic] background as me." 2020
"I was able to improve the breadth of my thinking about an issue. In the past I would often stick with the first thought that came to mind because I felt I had to have a firm opinion but through this class I have learned that my opinions can be bigger, more complex, and ever changing at the same time." 2020

Pedagogical Changes Made in Response to Student Feedback

In response to student feedback, we have made the following changes over the first three offerings of the course: 1) do not cold-call students, 2) give more students a chance to speak during in-class debates, 3) allow students to have input on debate topics, and 4) allow students more freedom for their final paper.

For class discussions, we had to resist the urge to "cold-call" students. In an effort to prepare students to volunteer, we allowed students more time to talk in small groups before opening up discussions as a class. Before breaking into small groups for

discussion, we ask a few groups to be prepared to share something when we come together as a class.

After the first in-class debates, we made two changes to give more students an opportunity to speak. We decreased the size of teams and used two classrooms, so that we had two debates running simultaneously. In addition, we provided less structure for the second debate (e.g., opened up debate to individuals immediately following the opening statement, instead of having teams present one rebuttal for the whole team). For the future, students suggested that they would like to brainstorm and vote on the debate question instead of being given the question by the instructor.

Finally, students suggested an alternative assignment in lieu of the final paper for the course, such as a presentation or art piece. We offered this alternate format in the second and third offerings, but few students took advantage of it. One student made a video describing her project. One student reflected on how her rough draft of the final paper contained biased language and research, which was an interesting progression of her analysis. We are considering in future quarters to encourage students to carry on their team projects or final paper ideas through service and leadership opportunities.

Conclusion: Engineering Students Enjoy Learning About Social Justice

We describe the development of a new curriculum, "Science and Engineering for Social Justice," a 5-credit course that explores social justice in a science and engineering context, with specific focus on race, gender, sexuality, and disability. This course content is important for all engineering students, and is appropriate for all undergraduate majors.

We have received overwhelmingly positive student evaluations from the first three offerings of the course. We discuss the positive aspects of the course material, what students learn about themselves from the class, and changes we have made in response to student feedback.

In this paper, our aim is to make teaching about social justice issues more manageable for engineering educators. Our goal is for other engineering educators to use our curricular materials, instructor observations, and analysis of student impact to create a class activity, module, or course curriculum. The curricular materials and insights from this paper are interdisciplinary and transferable to many courses in BME and related fields.

Bibliography:

[01] Riley, Donna. (2008). Engineering and Social Justice. *Synthesis lectures on engineers, technology, and society* (1st ed., Vol. 3, Synthesis Lectures on Engineers, Technology and Society). San Rafael: Morgan & Claypool.

[02] The Center for Critical Race and Digital Theories. Website: https://criticalracedigitalstudies.com/syllabus/. Accessed 19 Apr. 2021.

[03] Jean Stefancic & Richard Delgado, Critical Race Theory: An Introduction, (2010). Available at: https://scholarship.law.ua.edu/fac_working_papers/47. Accessed 19 Apr. 2021.

[04] Winner, Langdon. "Do Artifacts Have Politics?" *Daedalus*, vol. 109, no. 1, 1980, pp. 121–136. *JSTOR*, www.jstor.org/stable/20024652. Accessed 19 Apr. 2021.

[05] Lord, S. M., & Olson, R., & Roberts, C. A., & Baillie, C., & Dalrymple, O. O., & Perry, L. A. (2020, June), *Developing Changemaking Engineers – Year Five* Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual Online. 10.18260/1-2—34427.

[06] Engineering Education for Social Justice: Critical Explorations and Opportunities. Editor Juan Lucena. Springer 2013. DOI 10.1007/978-94-007-6350-0.

[07] Adams, Maurianne, Lee Anne Bell, and Pat Griffin (Editors), *Teaching for Diversity and Social Justice: A Sourcebook*, Routledge, 2nd Ed., 2007.]

[08] The National Academy of Engineering Center for Engineering Ethics and Society https://www.nae.edu/26187/CEES. Accessed 19 Apr. 2021.

[09] The Ohio State University, Advancing Technology That Promotes Social Justice for Humanity. https://hevcp.engineering.osu.edu/. Accessed 19 Apr. 2021.

[10] Engineering, Social Justice, and Peace network. http://esjp.org/. Accessed 19 Apr. 2021.

[11] "Intelligent Machinery, Identity, and Ethics" course website https://intelligentmachinerycourse.com/. Accessed 19 Apr. 2021.

[12] Johnson, K., & Leydens, J. A., & Moskal, B. M., & Silva, D., & Fantasky, J. S. (2015, June), *Social Justice in Control Systems Engineering* Paper presented at 2015 ASEE Annual Conference & Exposition, Seattle, Washington. 10.18260/p.24715.

[13] Leydens, J. A., & Lucena, J. C., & Nieusma, D. (2014, June), *What is Design for Social Justice?* Paper presented at 2014 ASEE Annual Conference & Exposition, Indianapolis, Indiana. 10.18260/1-2—23301.

[14] Schiebinger, L. "The Anatomy of Difference: Race and Sex in Eighteenth-Century Science." Eighteenth-Century Studies, Vol. 23, No. 4, Special Issue: The Politics of Difference (Summer, 1990), pp. 387-405. Published by: The Johns Hopkins University Press. Sponsor: American Society for Eighteenth-Century Studies (ASECS). Stable URL: http://www.jstor.org/stable/2739176. Accessed 19 Apr. 2021.

[15] Buranyi. S. (2017) “Rise of the racist robots: how AI is learning all our worst impulses.” The Guardian. https://www.theguardian.com/inequality/2017/aug/08/rise-of-the-racist-robots-how-ai-is-learning-all-our-worst-impulses. Accessed 19 Apr. 2021.

[16] Zou, James, & Schiebinger, Londa. (2018). AI can be sexist and racist - it's time to make it fair. *Nature (London), 559*(7714), 324-326.]

[17] Howard, Ayanna, & Borenstein, Jason. (2018). “The Ugly Truth About Ourselves and Our Robot Creations: The Problem of Bias and Social Inequity.” *Science and Engineering Ethics, 24*(5), 1521-1536.

[18] Lo Piano Samuele. (2020). Ethical principles in machine learning and artificial intelligence: Cases from the field and possible ways forward. *Humanities and Social Sciences Communications, 7*(1), 1-7.

[19] Schiebinger, L. ”Skeletons in the Closet: The First Illustrations of the Female Skeleton in Eighteenth-Century Anatomy.” Representations, No. 14, The Making of the Modern Body: Sexuality and Society in the Nineteenth Century (Spring, 1986), pp. 42-82. Published by: University of California Press. Stable URL: http://www.jstor.org/stable/2928435. Accessed 19 Apr. 2021.

[20] Riley, Donna, Pawley, Alice L, Tucker, Jessica, & Catalano, George D. (2009). Feminisms in Engineering Education: Transformative Possibilities. *Feminist Formations, 21*(2), 21-40.

[21] C. Gunnarsson, C. Birch, and D.G. Hendricks. “Exploring the Interplay of Diversity and Ethics in an Introductory Bioengineering Course”, Pacific Northwest Section Conference, American Society for Engineering Education, Seattle WA. (April 2017)

[22] C. Birch, C. Gunnarsson, and D.G. Hendricks. “Work in Progress: Exploring the Interplay of Diversity and Ethics in an Introductory Bioengineering Course.” American Society for Engineering Education Annual Conference, Salt Lake City, UT. (June 2018)

[23] C. Gunnarsson, C. Birch, and D.G. Hendricks “Design and Implementation of an Engineering for Social Justice Curriculum.” Collaborative Network for Engineering and Computing Diversity (CoNECD) Annual Conference, Crystal City, VA. (2019)

[24] National Academy of Engineering (2008). Changing the Conversation: Messages for Improving Public Understanding of Engineering.

[25] Hess, J.L. and Fore, G. (2017) “A Systematic Literature Review of US Engineering Ethics Interventions.” Science and Engineering Ethics. DOI: 10.1007/s11948-017-9910-6.

[26] Herkert, J.R. (2010) “Engineering ethics education in the USA: Content, pedagogy and curriculum.” European Journal of Engineering Education, 25:4, 303-313. DOI: 10.1080/03043790050200340

[27] Martin, E. (1991) “The Egg and the Sperm: How Science Has Constructed a Romance Based on Stereotypical Male-Female Roles.” Signs, 16(3): 485-501. The University of Chicago Press. Stable URL: http://www.jstor.org/stable/3174586

[28] Eveleth, R. (2015) “The Exoskeleton's Hidden Burden. The Atlantic. https://www.theatlantic.com/technology/archive/2015/08/exoskeletons-disability-assistive-technology/400667/

[29] Documentary: “Fixed: The Science/Fiction of Human Enhancement.” https://www.fixedthemovie.com/

[30] Villarosa, L. (2019) “Myths about physical racial differences were used to justify slavery – and are still believed by doctors today.” New York Times: 1619 Project. https://www.nytimes.com/interactive/2019/08/14/magazine/racial-differences-doctors.html

[31] Miller, M. (2014) “Black and white lungs: race and the history of spirometry.” The Lancet: Respiratory Medicine.” DOI:https://doi.org/10.1016/S2213-2600(14)70175-4

[32] Williams, David R, & Cooper, Lisa A. (2019). Reducing Racial Inequities in Health: Using What We Already Know to Take Action. *International Journal of Environmental Research and Public Health, 16*(4), 606.].