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Centering Social Justice in Engineering: A New Course Model for First-year Engineering Education

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Introduction

This complete evidence-based practice paper shares a new model for a first-year engineering course that centers social justice within first year engineering education. The course combines technical and social justice content with a goal of developing student understanding of the relevance of social justice to their future as engineers. Included in the course are social topics related to belonging, identity, inclusion, privilege, power, oppression, and allyship as well as technical topics such as 3D visualization, design process, orthographic projection, and the role of failure in design. This paper presents the course model, shares learning objectives, details the unique features of the course, and shares research findings related to the course. Course assignments make use of a flexible grading structure that allows students to tailor their learning to align with their prior knowledge and educational goals. The paper discusses how the authors blend the social and technical to create continuity and connection between the course topics to help students develop a sociotechnical mindset. A student survey was developed to assess the impact of the new curriculum on student understanding of social justice and students' perception of the relevance of social justice to the profession. Student evaluations and written reflections were also examined to gauge how students perceived the integration of social justice into an introductory engineering course. Survey results indicate that student awareness of the relevance of social justice to the engineering profession increased over the course of the quarter. In addition, findings indicate an increase in understanding of social justice concepts along with an increase in ability to identify social injustice. As seen through course evaluations and written reflections, student response to the course has been positive and most students are receptive to social justice education being part of the introductory engineering education experience. The results of this study provide insight into the impact of integrating social justice into engineering coursework and can help provide rationale and support for creating new or updated intersectional curriculum. This work may be of interest to faculty and programs looking to integrate social justice into the first-year engineering experience.

Literature Review

Understanding the role and relevance of social justice to the engineering profession is an important but often overlooked component of engineering education. Engineers, being on the forefront of technological change, have tremendous impact on creating change that benefits society. Furthermore, the profession plays a key role in addressing global inequity and injustice. Enabling engineers to address complex technological challenges like climate change requires the development of new skills such as evaluating justice dimensions of engineering and collaborating with diverse communities [1].

Conventional engineering education emphasizes technology-based attributes such as analytical skill development, technical knowledge, and creative problem solving and leaves little time for students to deeply engage with the social implications of their work [2] [3]. However, in recent years, there has been an increased effort to incorporate social justice into engineering education

[4-9]. One method has been to encourage students to take social justice-based electives offered by humanities and social science departments, an approach that tends to perpetuate the division between social and technical work [10]. There are also examples of curricula that integrate social justice into design projects, project based learning activities, and team based assignments however, in most cases, this is done using fairly broad swipes with the emphasis still being on the technical solutions [10] [11]. Although this is a good start, much of the work upholds vertical power relationships between the expert (engineer) and the user (society) and thus, perpetuates systemic inequity [11] [12]. These approaches can undermine student perceptions of the importance and relevance of social justice to the work of an engineer. This can leave students unprepared for the sociotechnical reality of the workplace and, worse, can perpetuate the technocentric nature of engineering, leaving students to believe that reducing inequity and preventing injustice comes second to technological advances [13] [2].

Cech (2013) explains that most students do not see social justice as being relevant to their future profession due to a "culture of disengagement" where students disassociate social and political issues from an engineers' work [14]. The highly technical focus of engineering education has effectively marginalized social components and thus, limits student engagement with considerations of public welfare [15] [16]. As such, engineering students typically have a difficult time critically analyzing the impact of their work on public welfare and society, especially in the context of creating a more equitable and inclusive society. Recent research has shown that student interest and commitment to social responsibility declines as students' progress through their academic career [2] [17]. Furthermore, although the majority of engineering curriculum includes considerable and meaningful ethics education, it often excludes discussion and connection to larger societal issues and social justice content [18].

The importance of social justice has been echoed by many engineering organizations, corporations, and businesses through their mission statements, core values, diversity commitments, and strategic initiatives. ABET has recently revised their criteria for accreditation to include a deeper focus on social impact, cultural responsibility, and ethical considerations [19]. In addition, many professional societies and organizations have updated their mission statements and core value statements to focus on promotion of socially just education and action, often with emphasis on improving diversity, creating a more inclusive culture, and increasing equity. For example, the Society of Manufacturing Engineers (SME) diversity statement professes that SME is "commit[ed] to promoting diversity and inclusion of all within our community" and "believe[s] that diverse perspectives and talents are essential within manufacturing research" [20]. Similarly, the Society of Women Engineers lists "inclusive environment" as one of their 5 core values and commits to "demonstrate the value of diversity and inclusion" as part of their mission statement [21]. These missions, goals, principles, and value statements go beyond a focus on understanding the impact of engineers' work and actions on society and include a commitment to creating a more diverse profession whose constituents value and uphold a commitment to inclusion and equity.

Integrating social justice into engineering education does not come without challenges. The literature describes the primary challenges being student resistance; lack of faculty training and discomfort with subject matter; and packed curriculum along with issues associated with accreditation [22-24].Furthermore, for most engineering faculty, it requires learning,

perseverance, reflection, commitment [5] [25]. Despite the challenges, it is important for engineering programs (and faculty) to commit to doing this work as it is an essential component of educating future engineers.

Internal Motivation & Course Development Process

Western Washington University (WWU) is a public institution with approximately 15,000 full-time undergraduate students. The Engineering and Design Department (ENGD) at WWU has four undergraduate-only programs: Electrical & Computer Engineering (EECE), Industrial Design (ID), Manufacturing Engineering (MFGE), and Polymer Materials Engineering (PME). Students interested in majoring in engineering at WWU must formally apply to a program after completing a series of prerequisite courses. Prior to being accepted into a program, students are considered pre-majors. There are approximately 250 - 350 pre-major students and 300 major level students enrolled in ENGD programs.

In fall 2018, a group of ENGD faculty conducted an internal review of the ENGD programs through analysis of departmental institutional data and a student survey on belonging. The department learned that 1. pre-major and underrepresented students have lower sense of belonging than their counterparts, 2. there had been a significant decline in women and people of color entering the programs, and 3. new majors were lacking cultural competency and communication skills. In Fall 2019, the authors surveyed and interviewed department faculty to get feedback on how, as a department, WWU ENGD could best address the above issues and better prepare students for the major. That process resulted in the department wide decision to create a new 100-level course sequence that introduces students to engineering in a way that emphasizes and promotes social justice, student engagement, and cultural competency. ENGR 101: Engineering, Design, and Society is the first course in that sequence and is the subject of this study.

The Course - ENGR 101: Engineering, Design, and Society

With the goals of introducing students to engineering while building foundational knowledge of social justice and developing cultural competence an introductory engineering course, Engineering, Design, and Society (ENGR 101), was created for first year engineering students at WWU University in Fall 2019. The course was designed to highlight the relationship between engineering, design, and society and to create inseparable connections between those three elements. ENGR 101 is a graduation requirement for the ID, PME, and MFGE programs and is highly suggested for EECE students. Students take the course during their first year of study, typically during the first or second quarter. The class is 2 credits and meets twice per week for 50 minutes. It does not have any prerequisite requirements and is open to any student interested in engineering as a major. The objectives of the course are to 1. introduce students to the field of engineering and design, 2. center social justice as integral to the profession, 3. foster student sense of belonging in the pre-major; and 4. promote and encourage student engagement and inclusion.

Course Description: ENGR 101 (2 credits) introduces students to field of engineering and design and explores the relationship between engineering, design, technology, and society. The course provides a structure for students to explore and understand the role of social justice in engineering and design while developing foundational skills necessary for student success. Topics include societal impact of technology, the relevance of social justice in the engineering and design profession, ethical decision making, and social mindfulness in design.

Course Learning Outcomes:

- Demonstrate knowledge of the engineering and design professions and associated technologies.
- Conceptually explain the design process.
- Explain the role of social justice in engineering practice
- Effectively communicate knowledge and understanding of professional ethics and responsibility.
- Describe how contemporary issues impact engineering design and practice.
- Reflect on how your life experience, privilege, and culture affect the way you may practice engineering and/or design.

Course Themes: The major course themes for ENGR 101 are shown in Figure 1: ENGR 101 Course Topics. Each theme corresponds to one or more of the course learning outcomes and includes both technical and social justice concepts.

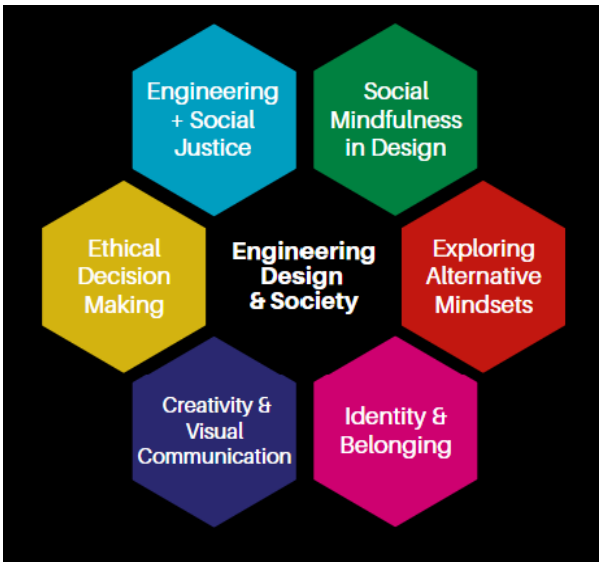

Figure 1: ENGR 101 Course Themes

Course Topics: The course is designed to blend the social and technical concepts to create continuity and connection between the course topics. The goal is to aid students in developing a sociotechnical mindset. All engineering topics have social justice components and all social justice topics are connected directly to engineering. Specific course topics include social identity, belonging, systems of power and privilege, mindfulness in decision making, cultural competence, ethics, social responsibility, and the societal impact of technology. The course also

includes an introduction to technical topics such as 3D visualization, the design process, and orthographic projection. Engineering topics are the focal point during weeks 1, 3, 5, 7, and social justice topics are a focal point for weeks 2, 4, 6, 8. As shown in *Table 1: Course Content by Week*, every week consists of both engineering and social justice content to help deconstruct the "culture of disengagement" that is prevalent in engineering [2].

Table 1: Course Content by Week

Weekly Theme	Engineering/Technical Content	Social Justice & Engagement Content
ENGR: Introduction to Engineering & Design	General definitions: engineering, design, innovation Department information Program information	Classroom norm setting Personal reflection Department tour Connections to peer mentors & supports
SJ: Identity & Belonging	Data on belonging in STEM Examples of equity in STEM How identity pertains to engineering (case studies)	ADEI definitions Bias & Prejudice Social Identity Wheel Story Sharing
ENGR: How Engineers Make Decisions	Engineering design process Role of failure in design	Socially just mindset & contexts Social impact of product/design development
SJ: Exploring Alternative Mindsets	Engineering Mindset Examining the engineering stereotype Privilege Case Study – examples from engineering	Intersectionality Stereotypes Privilege Social Justice Mindset
ENGR: Creativity & Visual Comm	Spatial visualization Intro to graphics Basic sketching	Spatial vis data & STEM Success Mid-quarter support from counseling & wellness
SJ: Oppression & Allyship	Case study: Racism in ENGR Design approaches that promote social justice Allyship in industry scenarios	Prejudice Discrimination Oppression Allyship
ENGR: Orthographic Projections	Isometric sketching Orthographic projection Design drawings	History of CAD - limits/impacts Engineering as a tool for change Impact of prior learning
SJ: Social Responsibility & Ethics	Engineering ethics Professional responsibility Ethics of self driving cars Bias in design (case studies)	Social responsibility Social identity & ethics Personal vs professional ethics Impact of engineering decisions
Reflecting Back & Moving Forward	Support social change & challenge injustice What should engineers ask themselves in their lives and work to further social justice?	

Flexible Grading Structure: In alignment with inclusive teaching practices, ENGR 101 is graded using a flexible grading structure. The structure is designed to meet individual needs of students and to foster student agency in developing learning goals. The course is graded out of a total of 25 points. Every assignment is worth 1 point and the course project is worth 5 points. There are between 30-35 points available, so each student chooses how they want to earn their 25 points. At the beginning of the quarter, every student completes a "self-assessment" where they identify their personal areas of strengths and weaknesses in relation to the course topics. With the help of the instructor and teaching assistant, the students make a list of the course assignments they plan to complete, with a focus on choosing assignments that will help them prepare for their future. For example, if a student has never used CAD before and know they want to be an MFGE major, they can complete an assignment focused on learning the basics of TinkerCAD or could choose to do the CAD based project.

Course Assignments & Class Activities: All course assignments and class activities were developed using best practices for inclusive teaching which includes pedagogical practices that improve sense of belonging and self-efficacy [26]. The quarter starts with development of course norms which are edited as necessary and then agreed to by each student. The norms are revisited and revaluated multiple times throughout the quarter to ensure an inclusive classroom environment is maintained [27]. Course assignments fall into one of three categories as shown in *Table 2: ENGR 101 Course Assignment Categories*. Every week students are assigned a weekly reflection which provide an opportunity for them to reflect on the weekly lessons, demonstrate comprehension of key ideas, ask questions, explore topics not covered in class, and connect learning to outside knowledge. A significant number of course assignment options are "engagement opportunities" which typically involve student participation in department activities and events. The goal of the engagement assignments is to aid in the development of sense of belonging to the department by encouraging students to attend department events and activities and/or to connect with other students. Finally, all students complete a course project. Like other course assignments, the project is designed to support student personal learning goals and there are multiple options to choose from. Students who have yet to decide on a major are advised to complete the "major exploration" project where they meet faculty, connect with peer mentors, and interview an industry member (often an alumni). On the other hand, students wishing to learn more about the connection of social justice to engineering are encouraged to join a discussion group focused on a book or podcast (examples of past book selections include *Invisible Women: Data Bias in a World Designed for Men* by Caroline Criado Perez and *Toxic Communities: Environmental Racism, Industrial Pollution, and Residential Mobility* by Dorceta Taylor).

Table 2: ENGR 101 Course Assignment Categories

Course Assignment Categories	**Examples**
Reflections/Discussions	Reflection (assigned weekly) Story sharing Product failures Stereotypes in engineering The ethics of AI
Engagement Opportunities	Club events

	Makerspace events "Outside the Lab" department speaker series Campus lecture or seminar Volunteer opportunities (dept, university, community) Earn a makerspace or department digital badge Spatial visualization workshops Learn how to make a simple CAD model Meet with the peer mentors
Course Project (choose 1)	Major exploration Makerspace project Learn how to use CAD Discussion group (book, podcast, or film) Ethics case study

Each class consists of one or more class activities focused on active learning. Course activities include discussions, case studies, role playing, think-pair-share, jigsaws, short design projects, sketching exercises, and more. Examples of class activities include drafting an engineering decision-making context that incorporates the social justice mindset, analysis of the benefits and costs of recent engineering innovations, case study of racism in engineering, role plays of allyship, and examining examples of bias in design.

Data Collection/Methods

The research questions that were explored as part of this study were 1. How and to what extent does the course impact student understanding of social justice? 2. How do students perceive the relevance of social justice to the engineering profession? and 3. How do students perceive the integration of social justice into an engineering course? The research questions were evaluated using both quantitative and qualitative data analysis through a student survey, written course reflections, and course evaluations. The research study received Institutional Review Board approval and participants completed an informed consent form at the start of the quarter.

Student Survey

A student survey was developed by department faculty to assess the impact of new 100 level curriculum on students' perceptions and understanding of ethics, professional responsibility of engineers, and social justice. The survey includes four main components: professional responsibility, ethics, social justice, and demographic questions. The questions on professional responsibility and ethics were adapted from the Engineering Professional Responsibility Assessment [28] and the Canney Ethics Survey [17] respectively. The social justice questions, which are the focus for this study, were developed by department faculty and were adapted from the WWU "Diversity, Equity, and Inclusion" survey that is administered to all WWU students annually. The survey instrument is part of a larger research study with large scope research questions focused on analyzing the impact of new courses and updated curricular elements on student learning, social awareness, preparedness, and perceptions of engineering culture. For the context of this paper, the authors use the segment of the survey focused on the research questions to investigate the impact of this one course on student perceptions of social justice.

Quantitative and qualitative survey data was collected September 2021 through December 2022 for five separate offerings of the course (n=156). All offerings of the course were taught by the same instructor and each class filled to capacity (36 students). Students were administered a pre-survey during the first week of the quarter followed by a post survey in the last week of the quarter. The authors examined pre- and post- data of survey respondents and choose not to disaggregate based on demographics as that is part of a future study. The survey questions explored student familiarity with social justice concepts, interest in learning more about social justice, ability to identify social injustice, and importance of awareness of social constructs as professional engineers. The questions asked students to rate their agreement with statements along either a 7-point Likert scale from "strongly disagree" to "strongly agree" or a 5 point Likert scale from "not at all important" to "extremely important" as shown in Table 3: Social Justice & Relevance Survey Questions.

Table 3: Social Justice & Relevance Survey Questions

Survey Question	**Likert Scale**
I am familiar with the concepts of social justice I want to learn more about social justice I can identify social injustice I am interested in acting against social injustice	1-7 *1 – strongly disagree* *7 – strongly agree*
Awareness of social constructs such as race, gender, disability, and religion is important to my future career as an engineer Ability to recognize my own implicit bias is important to my future career as an engineer Being able to challenge your own assumptions is important to my future career as an engineer Feeling a sense of connection and belonging is important to the profession	1-5 *1 – not important at all* *5 – extremely important*
Is there anything that you would like to share about your experience this quarter?	Qualitative

Written Course Reflections

In addition to completing the surveys, all students were required to complete an open-ended reflective writing assignment on their experience in the class. Students were asked to respond to three open-ended prompts: 1. What did you learn in this class that was surprising to you? 2. What concepts or ideas discussed in this class interested and/or inspired you the most? 3. Considering all you have learned and experienced this quarter, what will you take with you into the future? For this study, the authors will share select student excerpts from the written reflections. In depth analysis of the written reflections will be completed as part of a future study and will be used to investigate causality.

Course Evaluations

End of the quarter course evaluations were administered to all students for the F21 and W22 sections of the course. An alternate version of student evaluations was administered in Fall 22 and are not included in this data set since they are not comparable. Course evaluations are

included in the study to show general student response to the course. The questions asked students to rate aspects the course along a 5-point Likert scale from "poor" to "excellent."

Results & Discussion

Student Survey Results

Summary statistics for the quantitative survey questions are summarized in Table 4: Quantitative Survey Results. Average scores for pre- and post- were calculated and data was analyzed using paired sample two-tailed t-tests to determine if survey results in any areas changed significantly between the pre- and post- surveys.

Table 4: Quantitative Survey Results

Question	Pre	Post	P-value
I am familiar with the concepts of social justice	**5.60**	**5.96**	**0.000****
I want to learn more about social justice	5.32	5.28	0.62
I can identify social injustice	**5.49**	**5.71**	**0.006****
I am interested in acting against social injustice	5.74	5.70	0.648
Awareness of social constructs is important to my future career as an engineer	**3.83**	**4.04**	**0.044****
Feeling a sense of connection and belonging is important to the profession	4.11	4.21	0.22
Ability to recognize your own implicit bias is important to my future career as an engineer	4.20	4.30	0.20
Being able to challenge your own assumptions is important to my future career as an engineer	4.49	4.42	0.33

** statistically significant at the $p \leq 0.05$ level`

Key results:

1. Student familiarity with the concepts of social justice increased
2. Students' ability to identify social injustice increased
3. Student awareness of the relevance of social justice to the engineering profession increased

The findings indicate that the course had an impact on educating students on social justice generally and increasing student awareness of the connection between social justice topics and the engineering profession. Also noteworthy is that students found other elements such as belonging, recognizing bias, and challenging their assumptions to be important to their career as they all scored above 4.0 (very important) in both the pre- and post- survey. This indicates that students are coming into the course having some recognition that these elements are relevant to their future as engineers.

The survey also included an open-ended question asking students if there was anything specific that they would like to share about their experience in the course. Of the responses (n=56), 51 were positive in nature and 18 specifically mentioned social justice as being a positive component of the course. Of the 5 negative responses, 4 were related to course assignments (ex: writing reflections are "tedious") and 1 student responded saying "there were a couple times I

felt excluded, but it wasn't detrimental, meaning I was able to make myself not be pushed out." *Table 5: Select Student Responses to Qualitative Survey Question* shares a selection of comments from students that focused on the social justice aspects of the course.

Table 5: Select Student Responses to Qualitative Survey Question

Is there anything that you would like to share about your experience in this class this quarter?
I didn't realize before how important it is to think about the social issues and how they affect everyone. I really enjoyed learning the material throughout this quarter.
I was expecting the social and ethics view in this class to be a waste of time, but now, I realize that both of those factors play a great part and role in the engineering and design world
I had a lot more fun learning about this aspect of engineering than I initially thought I would. Usually, I prefer the science and math part of engineering, talking about ethics and society didn't not interest me at first. I ended up finding it quite enjoyable to learn about it in class.
I definitely have a different but better perspective of how engineers can impact society. Prior to this course, I just focused on the technical aspect of engineering, but there is a bigger world outside of the engineering and design bubble.
I feel the course content regarding social justice was amazing. I have always seen engineering as a very utilitarian profession, with the sole purpose only being to succeed at a project, regardless of who was responsible. This course has shown me however that engineering can be, and very much should be, more than just that.
I have never attended a class that made their students feel so seen, safe and heard. Even though I am not pursuing engineering anymore, I would take this class 1000 more times.

The student responses above may indicate that the social justice content in ENGR 101 was somewhat unexpected and, in some cases, is initially seen as unnecessary in the context of an engineering course. However, the comments also suggest that students recognize that this content is, in fact, important and relevant. This is supported by the quantitative findings related to the increase in student awareness of the relevance of social justice to the profession.

Written Course Reflections

A total of 154 student written course reflections were submitted during the study. Included below are select comments from 5 students. Reflections will be examined more thoroughly in a future study however, they are included here to provide a sample of student feedback received with specific focus on the impact of the social justice component of the course. Of the reflections included below, there is evidence that students are thinking deeply about these topics. It is also clear that many of them still have questions and are interested in learning and/or doing more. Again, we see that some students were surprised by the inclusion of the social justice content but expressed that they understood the importance and relevance to engineering. One student mentions specifically that these topics are important part of an engineer's education. Another student discusses how the course helped them to develop a sense of belonging through dispelling engineering stereotypes.

Student 1: White, woman

I have been pleased to be part of a department that requires a course such as this, because I find it to be an integral part of a well-rounded engineering education. I believe the department should instate an entire series of courses that continue to discuss the issues of ethical design and decision making and social justice and responsibility in the context of engineering and design. The most surprising thing I learned in this class was that engineers are still making grave mistakes when it comes to making fair, ethical decisions pertaining to innovations. With social progress that has been made, it's too easy to believe that we live in a world where racism, ablism, and sexism are behind us, but the reality is we still see these discriminatory belief systems perpetuated via a myriad of social constructs, political agendas, and societal designs. I didn't know the extent to which they were also perpetuated through engineering and design. I was surprised to learn that there are many innovations and processes within engineering and design where entire groups of the population are forgotten about, or worse, knowingly discounted. Because ableism, racism, and sexism permeate into engineering and design, I would like to know more about how I, as a future engineer, can ensure any projects I am a part of do not feed these harmful systems. What discussions can I be a part of in my workplace that help ensure my innovations are accessible and fair to all? This is a question I will be researching more after the conclusion of this course.

Student 2: No demographics disclosed

I have always seen engineering as a very utilitarian profession, with the sole purpose only being to succeed at a project, regardless of who was responsible. This course has shown me however that engineering can be, and very much should be, more than just that. Being able to explore ideas such as social justice, stereotypes, implicit bias, and other topics has given me some of the tools to be a more open-minded person, which is how we will improve the idea of what it means to be an engineer; we won't be individuals who only see the end goal and nothing else, but so much more.

Student 3: White, man

The content we covered this quarter was not what I expected when I signed up for Engineering 101, but it turned out to be very interesting and a good foundation for my future in engineering. The big one that I didn't expect to be covered so thoroughly was on belonging, privilege, discrimination, etc. This turned out to be a lot of our work, which was good because it isn't a topic that I would have studied on my own. These lessons have led to some interesting conversations with friends about why we don't see more women in engineering and how that could affect how things get designed. I feel like it is important to learn about these things so that we can make sure to contribute to an accepting work environment and combat discrimination.

Student 4: White, woman

Before this class, I definitely had internalized a lot of common stereotypes about engineers and designers. For example, I thought of them as overly reliant on hard science and math, unable to stop working, socially awkward, lacking in empathy and compassion, obsessed with practicality, and resistant to change. Even though I knew

these things weren't necessarily true when I thought critically about them, they definitely still affected my sense of belonging and my confidence in interacting with others in the department. After taking this class, I feel like I have moved past many of those stereotypes and I feel more confident that I could belong in an engineering/design career. I think that engineers want to help people, and in many cases they have the skills required to fix problems people face; oftentimes, though, the larger systems in which engineers work block them from fighting for social justice and instead make them tools of the powerful.

Student 5: Man

What I expected when going into this course was a basic lecture and conversational class oriented around surface level inclusiveness and vague information about engineering. However, I can gladly admit to being wrong. While this course did cover topics of identity and diversity, stereotypes, and ethics, it was beyond the surface level and delved into the workings of each. This was a refreshing introduction class and made me care about engineering on a societal and individual level beyond seeing it as a career.

Course Evaluations

Data was collected through end of the quarter, quantitative student evaluations. Student evaluations are examined as part of this study to aid in evaluating research question related to students' perceptions of integration of social justice into an engineering course. Results from sections are summarized in *Table 6: Quantitative Course Evaluation Results*. The results show that all aspects of the course were rated between "very good" and "excellent." This is in line with course evaluations from other classes this instructor teaches, including technical courses such as statics and mechanics of materials. The course evaluations indicate that students were accepting of the course in general and were receptive of it being part of their educational experience. As mentioned previously, there is evidence that suggests students found the course content surprising and were not expecting such a strong focus on social justice. Evaluation results indicate that students did not rebel against ENGR 101 as their introductory engineering experience.

Table 6: Quantitative Course Evaluation Results from ENGR 101

Question	**Rating**
Overall course	4.53
Clarity of course goals and objectives	4.26
Organization of course	4.33
Answers to students' questions	4.62
Instructors' contribution to the course	4.71
Likert Scale: 1: poor; 2: fair; 3: good; 4: very good; 5: excellent	

Challenges

Although ENGR 101 has clearly had a positive impact on student understanding of social justice and is received positively by most students, that is not the case for all students. Even when there is just one student in the class who "opposes" the integration of social justice topics into engineering, it can be challenging for both the professor and other students in the class. Having a

cohort of faculty who teach the course is helpful because they can work together to address challenges and learn how to support students (and each other) [25]. Additionally, it can be helpful to provide professional development and training opportunities for faculty teaching these courses.

Conclusion & Future Work

With goals of centering social justice in engineering, the authors developed a new model for a first-year introductory engineering course that helps to bridge the gap between the traditional undergraduate engineering educational experience and the reality of the professional engineering practice. Sociotechnical thinking is important in the role of the professional engineer and will likely become more critical as we continue to face the complex challenges of a rapidly evolving world. Engineers must be able to critically examine the impacts of their innovations on society which includes environmental, economic, ethical, social, cultural and health and safety dimensions. This is complex work which often involves reflecting on our own personal values, understanding and respecting cultural differences, and navigation of interpersonal dynamics. Creating a structure for students to examine the complex responsibility of engineering decision making is critical, as is creating a space for them to share thoughts and opinions, especially when they may have different beliefs and values. ENGR 101 provides a platform for students to explore engineering in the context of social justice by closely linking engineers' works to social implications. It also provides opportunities for students to reflect on their own life experience, privilege, and culture and to think about how those things may affect the way they practice engineering. Students are provided with opportunities to explore critical questions such as "who gets to decide what problems engineers solve?" and "how can engineering be used to promote social justice?" and even "how can engineering serve as a force for equity?"

Findings from this study show an increase in students' understanding of social justice along with an increase in ability to identify social injustice over the course of one academic quarter. In addition, and perhaps more importantly, the course increases student awareness of intersectionality of engineering and social justice. The survey comments indicate that many students were surprised by the inclusive of social justice content, yet they acknowledged that it was important and relevant to their future. Course evaluations were overwhelmingly positive which indicates that students were accepting of the course content generally. The written course reflections may suggest that students are thinking deeply and broadly about the connections between social justice and engineering and that the course may have a positive impact on sense of belonging.

Future work involves conducting an analysis of student written course reflections and other related coursework to learn more about causality including student perceptions of the course, what (specifically) they are learning, to what extent they develop a sociotechnical mindset, and the impact on their sense of belonging. This will also involve an analysis disaggregated by demographics to examine potential differences by gender and race. Larger scope future work will involve providing additional opportunities for students to engage with social justice principles through the curriculum (at both the first- and second-year level) with the goal of developing a culture of engineering centered in challenging injustice, fostering peace, developing empathy, and addressing inequity.

This paper may be of interest to faculty and programs looking to integrate social justice into first year engineering courses and programs. The impact of ENGR 101 and courses like it have potential to be far reaching as it may help to dispel misconceptions about the work of engineers as being solitary technical practice. One could also argue that this work has potential to change the culture of engineering by working to deconstruct the many stereotypes associated with profession. By sharing course details and outcomes, the authors hope to inspire other faculty and programs to consider adding social justice content to 100 level engineering education.

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