# Race, Justice and Engineering Design - a pilot freshman engineering course

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## Abstract

The purpose of this ***practices paper*** is to share the process, experiences, and outcomes of redesigning a course for first-year engineering students to incorporate the concepts of race and social justice, and how they are critical in engineering design. The course is being offered as a pilot section that will eventually be provided to all first-year engineering students across all sections of the Intro to Engineering Design course. In this course, the main learning goals have traditionally been to have students understand the engineering design process at a basic level and understand what good teamwork is within the context of engineering design. The re-designed course keeps these goals, but also introduces the need to see, define, and communicate differences in your design and your team. To be an effective engineer, we believe you must fundamentally understand the difference between you and the customer/community you are designing for, as well as the team you are working with. In this pilot offering of the course, we introduce the concepts of race as constructed, race as intersectional, and race as global with video modules interviewing experts in these fields, created by Villanova Communications Department faculty. The students are challenged to incorporate these concepts into their teamwork, as well as to the engineering design process. Students discuss the realities of racism with engineering examples such as environmental racism, STEM educational desserts, and bias in coding. The students are given examples and case studies to work through and participate in nine facilitated dialogue experiences to learn to effectively communicate across difference. The facilitators are trained dialogue experts and run these sessions in smaller cohorts to build trust in the dialogue group. The designers of this course believe that implementing this in the freshman year will establish that all engineers at our university are expected to put the community first in their designs, as well as be actively anti-racist in their work. The paper will include data comparing the learning outcomes of the students in the pilot section of the course to those in the traditional sections of the introductory engineering course. Data was collected at the start and end of the semester and will measure students' perceived knowledge of the engineering design process, perceived ability to work effectively in a team setting, perceived understanding of social justice in the context of engineering design, and comfort level in discussing social justice issues.


## Introduction to the Race, Justice and Dialogue Course

At Villanova University, a group of Black students joined together to demand change, issuing a letter to the University President laying out some reasonable requests to improve the quality of life for Black students. While this letter could easily have been ignored, the president decided at the heart of their request, a push for social justice, was fundamentally part of the mission of the university. This set into action the development of not just a "DEI" course, but a course on race and social justice. The decision was to ground the course both in the Augustinian values that dictate the mission of the university, as well as the fundamentals for each discipline. This meant that each college had to work to develop a course that drew on the principles of race, social identity, and social justice within the context of their disciplines.

In order to empower faculty in these different disciplines to teach this course, a core group of faculty experts were brought together to develop content on social identity, race and social justice, and antiracist pedagogy. These experts put together a series of resources that are provided to the discipline instructors at a week-long training, along with follow up support throughout the development and implementation. The decision was made by this group that the incorporation of dialogue was critical to students reflecting on their own identity and learning to communicate across different identities effectively. Therefore, dialogue experts were hired and help co-facilitate these courses, which are known as Race, Justice and Dialogue courses (RJDC).

The aim of the RJDC is to expand and deepen students' critical consciousness of power and difference using an antiracist lens, and to promote student antiracist action in the service of social justice. Put differently, this course aims to expand students' antiracist literacy and advocacy in hopes of making Villanova, and beyond, more inclusive, equitable, and just for all.

The College of Engineering decided that this antiracist literacy and social justice advocacy is central to what many call "human centered" design. At Villanova University, the Augustinian values of Unitas, Veritas and Caritas (Unity, Truth and Love) are often consolidated as a focus on Community. This community centered focus, with an emphasis on love for all (Caritas) should be fundamental to our designs, and therefore was decided the best place to introduce this in the curriculum was in the freshman engineering design course. This paper describes the pilot RJDC in the College of Engineering's Introduction to Engineering Design course (EGR 1200).

## Course Design:

EGR 1200 is an introduction to Engineering design, how it handles difference, and through the Augustinian lens. It serves as a pilot section of the Race, Justice & Dialogue Course (RJDC) within the College of Engineering. As a section representing the College of Engineering, this course integrates innovative aspects of the RJDC course design, including pre-recorded modules as well as dialogue, with foundational knowledge of Engineering. The theme of the course is that engineers must be able to see, articulate, and account for differences (race, gender, socioeconomic, geographic, cultural, political) in their designs to be successful.

This course was divided into sections: the pre-recorded modules that all RJDC sections preview in class, dialogue, and disciplinary content related to Engineering. The disciplinary content was run by an Engineering faculty member and covered topics like engineering design and teaming as well as presenting the engineering material using a social justice lens that is anchored in notions of Caritas. The Engineering content will include lectures, hands on activities, and teamwork. Other class sessions will be dedicated to viewing and discussing the pre-recorded modules as well as dialogue. The dialogue sections of the class were run by two Dialogue Facilitators. Dialogue offers the individual and collective space to think critically and wrestle with the scholarship at a personal level through journaling and group dialogue. Students were invited to practice dialogic skills, self-reflect, and share their experiences, as well as to connect with, affirm and challenge their peers while exploring together the course content.

### Race & Social Justice

The race, identity and social justice concepts were introduced through a series of pre-recorded video modules that all students watched. These videos were high quality, directed and produced by communications experts (not just quick zoom recordings). The modules were divided into three different topics. The first was an introduction to the course (including that it was student driven), why university leadership feels antiracism is critical to our mission, and the history of our institution. This included how our Augustinian foundations have dealt with race, the erasure of the Lenape people who were the original people of the land our campus is built upon, and the former black slave who donated a large portion of the land that is now home to a predominantly white institution. The students were given a note taking guide to complete while watching this video (which was approximately 60 minutes) during the second week of class. The note taking guide asked some guided reflections that were then brought out in discussion the next class, including prompts on how learning these facts about Villanova made them feel. While some students were still skeptical about the concepts of this very unique course, many were encouraged to learn about the course development in response to a group of prior students' concerns.

The concept of erasure was further developed and incorporated with the desire to teach students how to do literary research, by having student teams research and present on an individual in STEM who was erased in history despite their contributions. Students had a presentation on good research practices and available resources from the Science & Engineering Librarian prior to this assignment. The teams then shared their results with the class, and everyone learned (including the instructor) from these presentations.

The second module focused on the concept of race. The module was divided into three parts, Race as a construct, race as global concept, and race and intersectionality. These concepts were difficult, and again a note taking guide was provided for students to use while watching the videos. The concept that race is a social construct, and not a biological classification (e.g. not in your DNA) was difficult for the students to gather from the video discussion. Therefore, the engineering instructors felt it was important to add time in class discussing different terms such as race, ethnicity, and nationality. We also discussed how these were simply terms generated by our brains desire to classify the world, and therefore classify people. In order for students to understand that it truly is a social concept, they were introduced to how DNA works, and that there is no DNA that codes for race. The concept of intersectionality was enforced further in the dialogue sessions and readings for those sessions. The dialogue facilitators believe the concept was introduced, but maybe not yet fully understood by many of these young students.

The final module that students watched focused on the realities of racism, the key takeaway being that despite race being a made-up concept, the impacts are real for people, especially nonwhite people in the United States. The examples included the impacts of race on education, housing, the environment in different neighborhoods, policing, sports, health equity and media. These were probably the most impactful videos of the series and gave concrete examples of how race has historically impacted, and continues to impact, one's life in the US. Student teams expanded upon these examples in many examples in the class such as;

- Identifying redline neighborhoods near where they grew up and overlaying the data on urban heat maps and health outcomes.

- STEM Education access by zip code – looking at which cities/states provided access to key gateway courses that are often required to enter engineering programs (high school physics, calculus, AP courses, etc.)
- The use of AI in police surveillance, with a heated discussion on the interest in campus police pursuing this on our own campus

In all of these examples, students then had to take the further step of looking at methods for engineers to do better. They had to propose methods to increase STEM access in schools, how the ASEE code of ethics requires us to challenge the NIMBY arguments (Not In My Back Yard) that privilege rich white neighborhoods, and what should be done to improve technology in police surveillance. These examples were mixed into the overall course discussion of engineering design, which is further detailed below in the next section. The student outcomes for the race and social justice section were that at the end of this course, students should be able to:

- explain key concepts related to the social construction of race, especially Whiteness, and the development of racism at the macro (institutional) and micro (individual) levels and how these social constructions have impacted engineering design and therefore actual communities.
- identify and critique how structures of power and privilege, both past and present, are rooted in racism and how such structures and how these power structures show up in the discipline of engineering and the practice of engineers.
- critically examine your personal beliefs, implicit biases, and opinions regarding your own race in relation to the race of others and to the broader social systems that have shaped your worldview as well as how the social identities of engineers as well as the discipline itself has privileged certain perspectives and experiences over others.
- formulate antiracist strategies or acts of allyship that combat racist attitudes, practices, and policies, especially as they relate to engineering design.

**Engineering Design**

The primary goal of this introductory course has always been to introduce students to the engineering design process. In order to be an effective engineer, design cannot be done alone, so teamwork and skills on effective teamwork are also important in this class. The design centers on the Augustinian value of Caritas (love of community), shown in Figure 1.

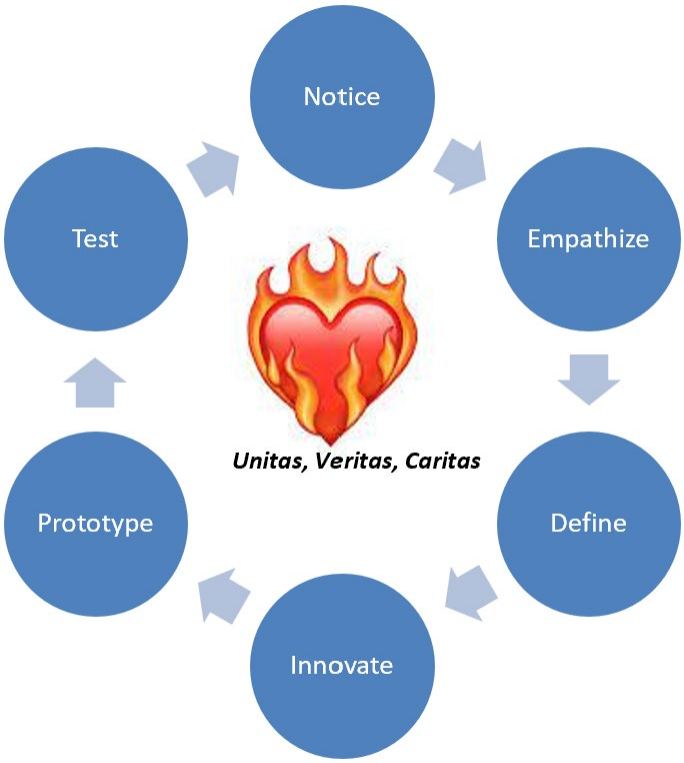



**Figure 1. Caritas Centered Design model used in this freshman engineering course.**

The students are also introduced to each discipline (Civil & Environmental, Chemical & Biological, Electrical, Computer, Sustainable and Mechanical Engineering), how it's unique and how they can work together. This is done by taking a step in the design process each week and using case studies and examples from a different discipline to evaluate that step. This is done as shown in Table 1.

| Design Step | Engineering Discipline | Design example activity |
|---|---|---|
| Notice/Empathize | Civil & Environmental Engineering | Students were asked to walk around campus and evaluate access to the campus train station and classroom building we were in for someone in a wheelchair |
| Define | Sustainable Engineering | Earth Boundaries, Social Justice Boundaries, cultural context |
| Innovate | Chemical & Biological Engineering | Plastic Usage on campus and better – brainstorm ideas for reducing waste |
| Prototype | Mechanical Engineering | Build a better toothbrush for a different customer base (e.g. someone with arthritis, a young |

| | | |
|---|---|---|
| | | child, a caregiver brushing someone else's teeth) |
| Test | Electrical & Computer Engineering | Design an inexpensive K12 circuit experiment to allow students to test basic circuit concepts (so any school could implement) |

**Table 1. Engineering Design Steps introduced by different discipline specific examples.**

The students were also asked to complete a team design project that addresses a need on campus and is larger than one day in class design experience. This design project was done in collaboration with the Office of Disability Services (ODS). The director of ODS asked the students to rethink the design of a freshman dorm for a student with a physical disability (this could be hearing or sight impairment, or physical disability). The students were given information from potential clients (current disabled students on campus) and also feedback on their initial prototypes from ODS as well as the Employee Resource Group (ERG) for Disabled Faculty and Staff.

The student design outcomes were that at the end of this course, students should be able to:

- understand and be able to implement engineering design.
- demonstrate whole system awareness with the ability to identify and understand interconnectedness (intersecting, related and/or connected systems; synergies and rebound effects) and how all human-made designs rely upon and are embedded within ecological systems.
- understand the importance of teamwork and how to be a good teammate for completing engineering designs.
- consider and understand tradeoffs and identify impacts of different parts of a system.

**Facilitated Dialogue Sessions**

Distributed across the 15 weeks were 10 dialogue sessions (75 minutes each) that were led by the trained dialogue facilitators. Since the pilot course had 24 students, the students were divided into two dialogue groups that stayed the same throughout the course, each with their own facilitator. The course instructor was not present during the dialogue sessions so that students could feel comfortable discussing difficult topics without the presence of an engineering faculty member.

The dialogue sessions focused on talking from the "I" perspective, how to actively listen, how to talk through difference/conflicting ideas. These skills were done by focusing on personal identity, how one's identity changed their journey to engineering (and limited on while in engineering since they were first semester freshman). Students were given readings on social identity, cycles of socialization, and other related topics that served as talking points to initiate the dialogue.

The engineering faculty designing the course see these skills as critical to being a good engineer, and directly related to the ABET student outcome to communicate across a variety of audiences. Effective communication is also critical in being a member of a team, which is an ABET student outcome as well. The student dialogue outcomes were that at the end of the course, students should be able to:

- demonstrate dialogic skills, including an ability to articulate one's perspective, listen, question, affirm and synthesize ideas.
- use dialogic skills to engage in meaningful interactions that allow and invite students to explore perspectives, explain further, reflect on what others say and listen for understanding.
- employ dialogic communication as action, community building and a way to affect change within systems and structures of power to address inequities and injustices.
- explore and identify the identities and the lived experience of the self and others through shared narratives to better understand one's intersectional identities, their positionality, and the placement of groups within systems and structures of power, as well as how and why systems of inequality persist.

**Assessment**

***Method***

Students in all sections of EGR 1200 were given a pre and post course questionnaire. The students in the traditional sections covered engineering design, teamwork, and basics on the different disciplines, but did not cover the race, justice and dialogue concepts. All students were given time in class to complete the exam on Qualtrics anonymously. Students had to be over 18 to complete the survey, and participation was optional. IRB approval was granted prior to conducting these surveys.

***Student Profile***

The pre-course survey included information on the profile of the students in the course. A total of 18 students in the pilot RJDC completed the pre course survey and 160 of the traditional (control) students. The students ethnicity as self-reported for each section is shown in Figure 2. The student gender split was 33% female, 67% male in the RJDC pilot, and in the control section was 47% female, 52% male, 1% prefer not to identify.

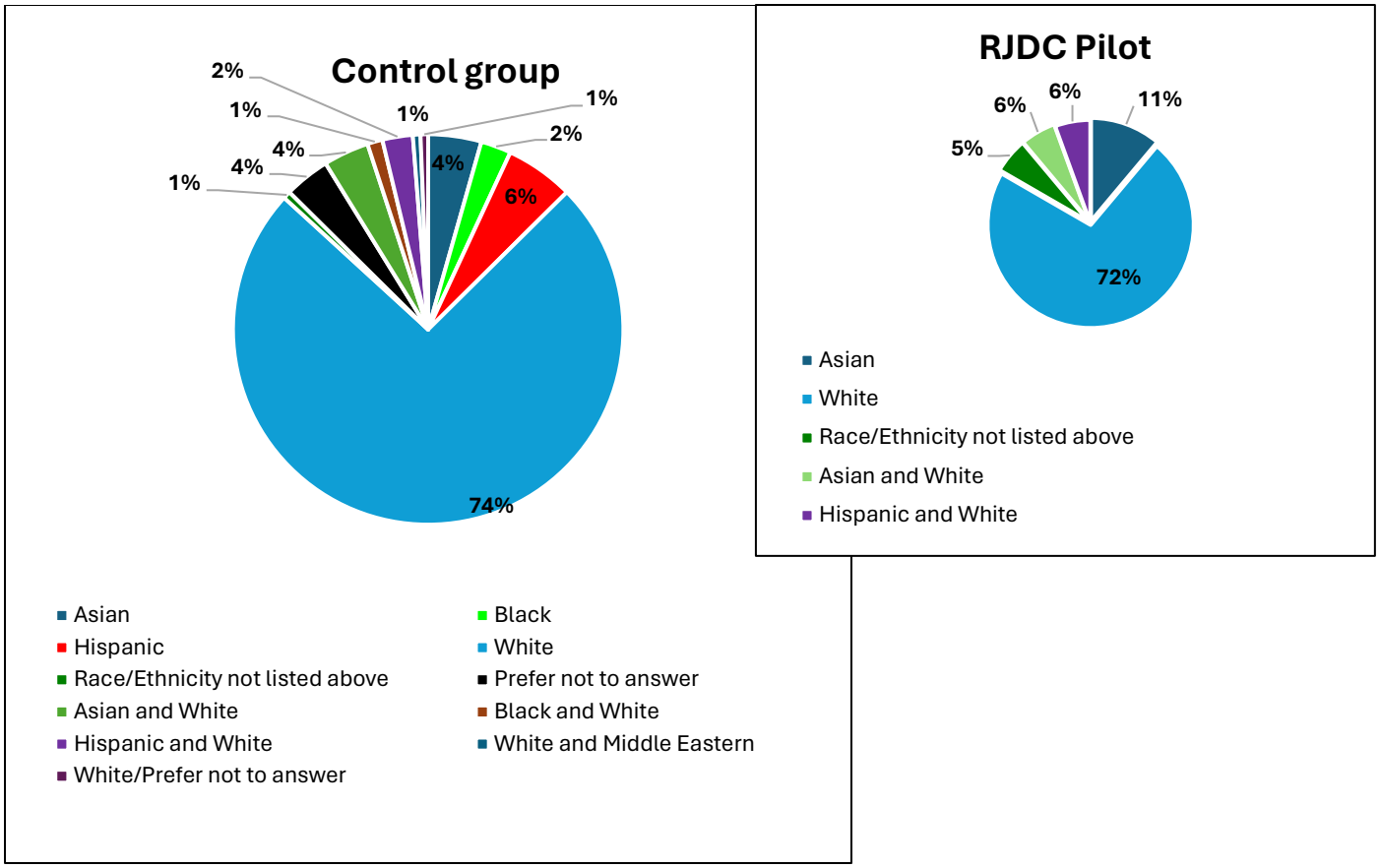



**Figure 2. Comparison of student ethnicity among the control and pilot sections.**

The students enter the University with a declared major in engineering, so the profile of students that responded was collected. There is a larger portion of mechanical engineering majors in the pilot section as compared to the control section that responded to the survey (Figure 3).

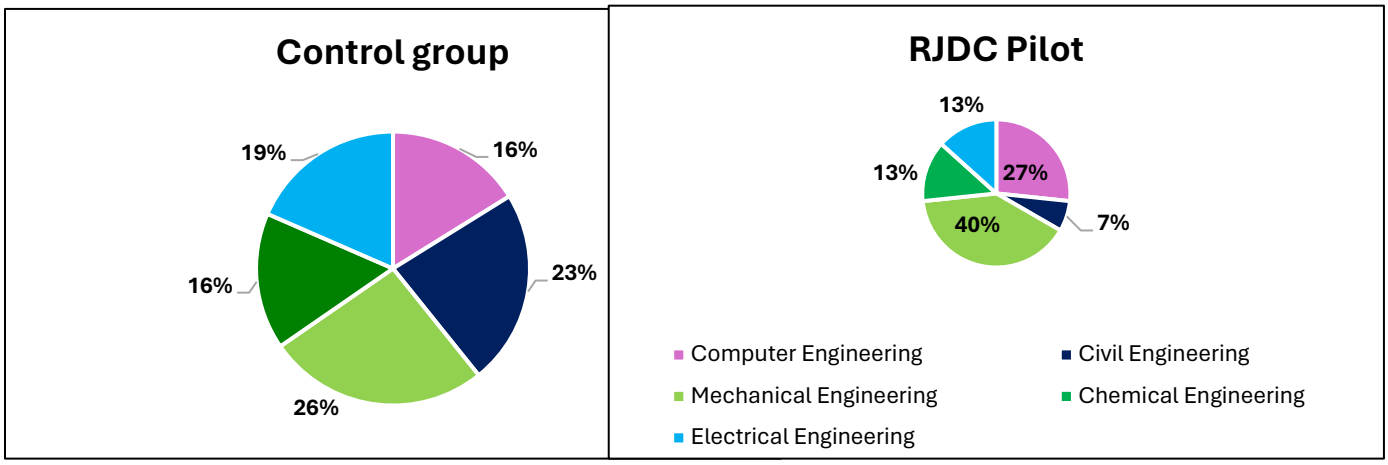



**Figure 3. Students declared majors prior in each of the sections of the first year engineering course.**

***Results***

In the pre course survey, students were asked to evaluate their confidence in several topics, such as engineering design and teamwork. In all questions, the students in the RJDC Pilot (which is also an Honors section) self-rated as more confident. This was not surprising that this group would be more confident (not necessarily more knowledgeable) going into the course (Figure 4).

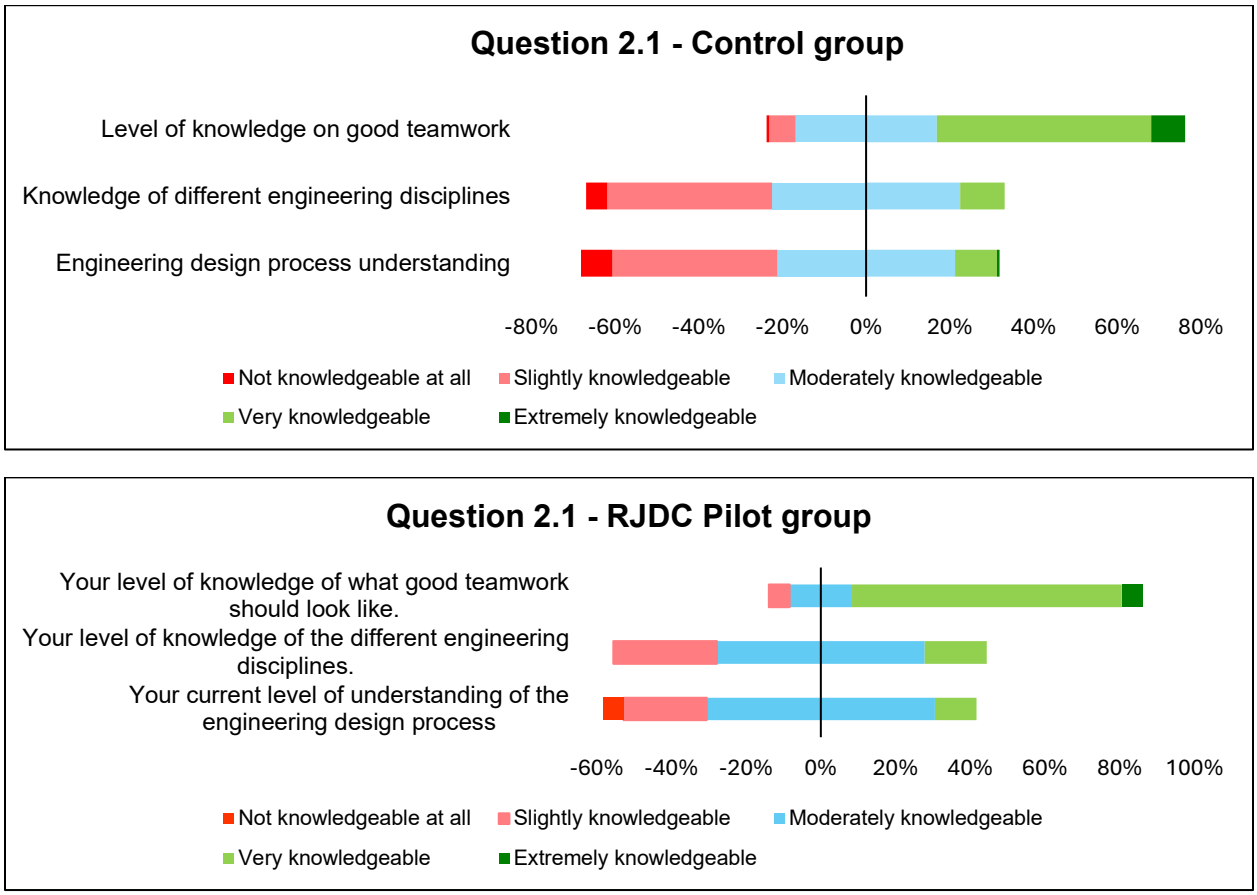



**Figure 4. Pre course confidence in engineering design and teamwork skills**

The students all had a strong sense of their ability to work on a team, but less so on their dialogue-based skills regardless of section (Figure 5), while the Pilot (honors) section had a stronger sense of their ability to listen, communicate and work on a team.

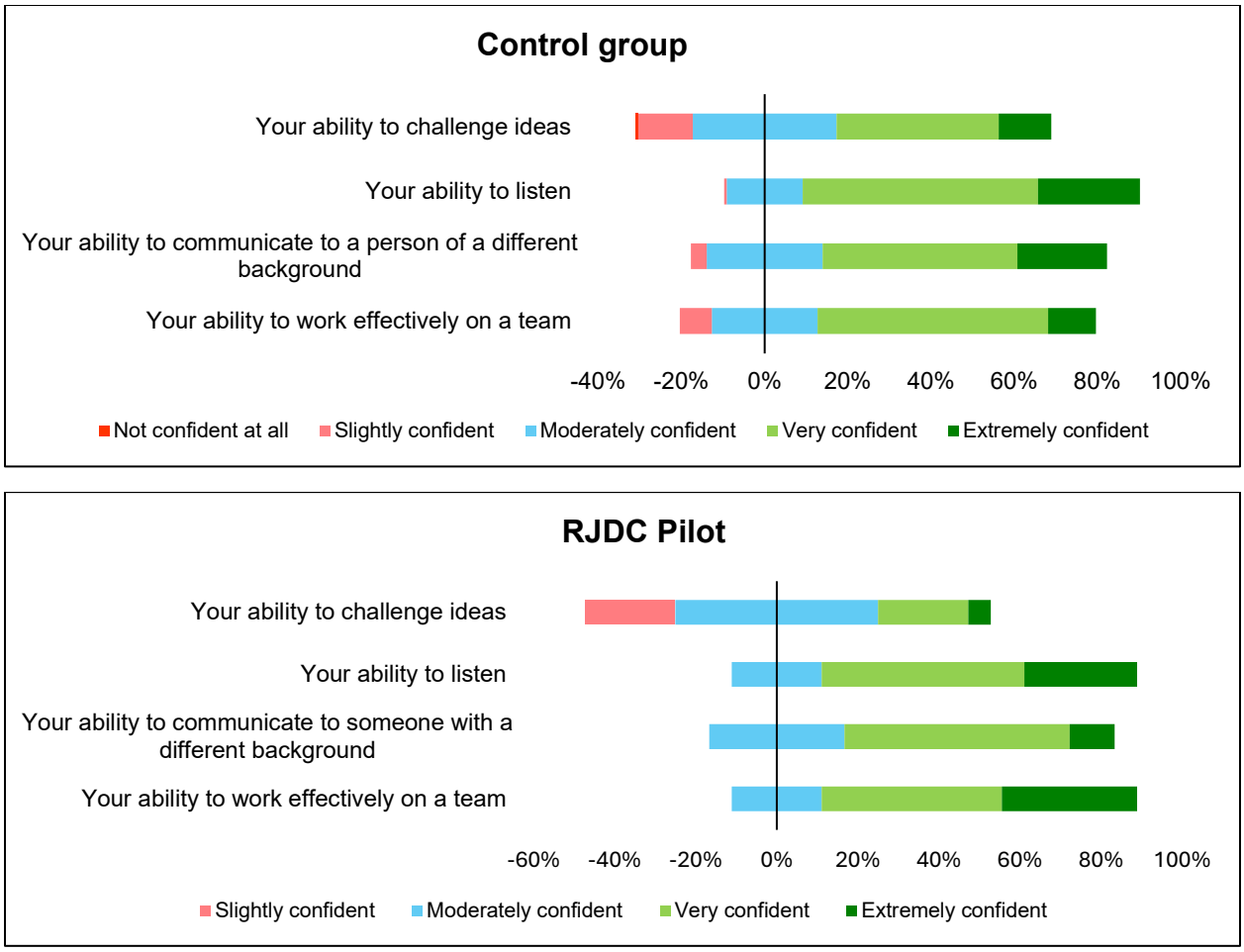
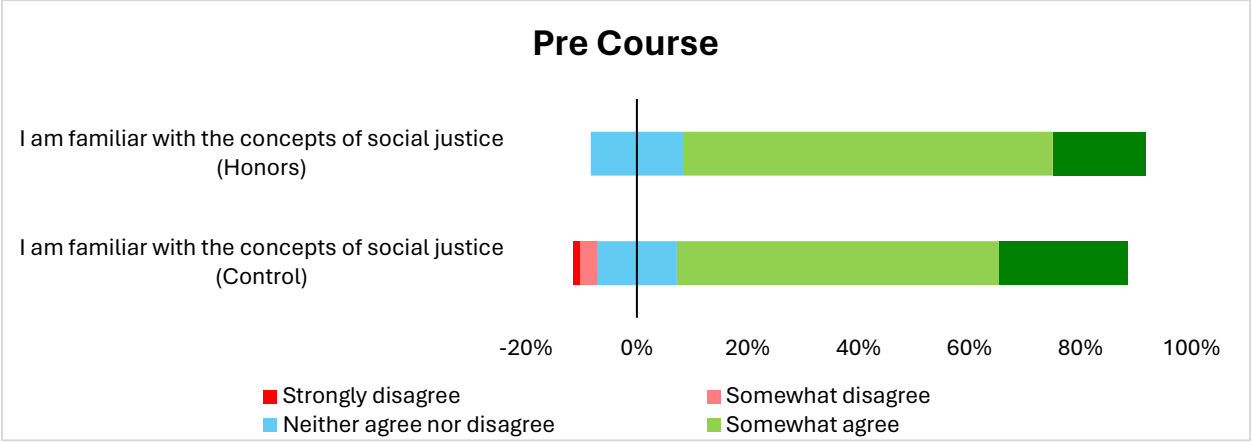



**Figure 5.** The students pre-course confidence in dialogue and teamwork skills.

Finally, students knowledge of social justice and its relevance to engineering was evaluated. Both the pilot and control sections ranked their skills lower in these questions (Figure 6).



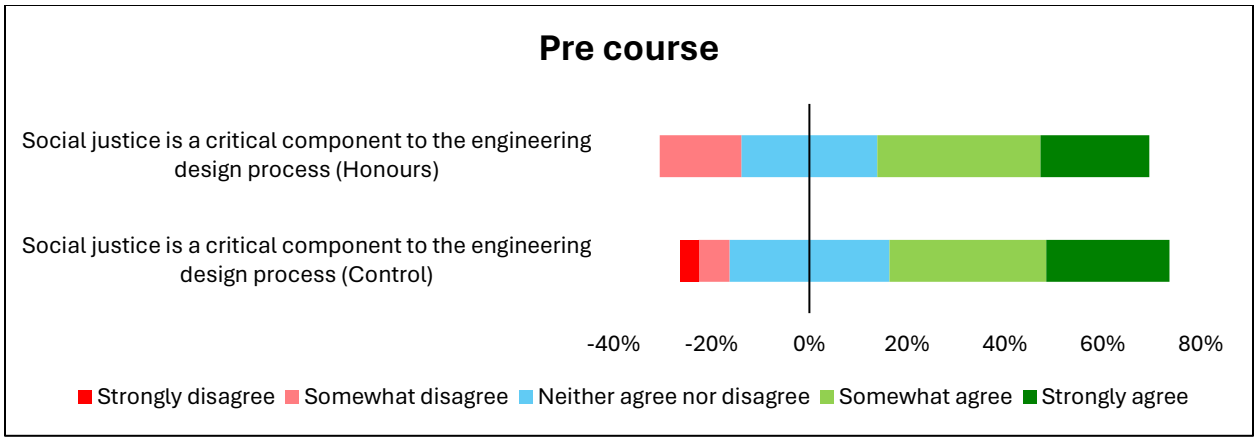



**Figure 6.** The students pre-course knowledge in social justice.

### Future Work

The team has collected the data for the post course analysis with the aide of the office that runs the student course and teacher evaluations, however the analysis on these is still underway. The course instructors feeling for the pilot section is that the students did increase their knowledge in social justice and did identify in the final dialogue that it was a critical component of engineering design. Their design projects and final reflection papers indicated they took the social justice content seriously, and identified the difference in their identities as compared to their teammates, reflecting on how this could change their experiences at the same university. All of the pilot sections final designs took into consideration feedback from the Office of Disability Services as well as the disabled students. Many teams took extra steps to find regulations, best practices, and even social media clips of a “day of a life in a dorm” for students with the specific disability they designed for. Overall, the pilot was deemed a successful learning experience, worth piloting again in the Fall 2024 to gather more data and refine the experience.