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Work in Progress: Enhancing Respectful, Equitable Teamwork in a First-Year Design Course

Dr. Michael Rizk, Duke University

Michael Rizk is an Assistant Professor of the Practice in the Department of Biomedical Engineering at Duke University. He is also the Associate Director of the First-Year Design program in Duke's Pratt School of Engineering. His interests include the first-year experience for engineering students, design courses, and introductory biomedical engineering courses.

William Ross Denton
Roxana Haas

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Abstract

This Work In Progress paper describes the initial implementation of activities aimed to enhance teamwork in a first-year design course. Teamwork plays a central role in the experience of students in many first-year engineering design programs. The first-year design class at Duke University revolves around student teams (typically four or five members) working on aspects of a client-based project. Although most teams in the course function reasonably well, there exist areas for improvement: respectful communication among team members and ensuring that the perspectives and skills of all group members are appropriately valued. Each year, a few groups have problems in these areas, creating a challenging environment particularly for underrepresented engineering students. To combat this issue, a video and activities were developed to emphasize teamwork and inclusion. The video was created by two students who had taken the course in the previous year. It presented background information, mindful teaching about inclusion, some discussion of the students' personal experiences in the course, and an introduction to the activities. The three activities that were developed were (1) a communication game, which allowed students to practice clear and respectful communication, (2) a teamwork and collaboration game, which aimed to show that each member of a team had something valuable to contribute, and (3) a reflection and discussion activity, which aimed to solidify ideas from the previous activities and allow students to reflect on how they could implement these teamwork and inclusion ideas into their teams. Students watched the video shortly after their teams were formed and completed the three activities in class the next week. Surveys completed after this portion of the course indicate that students felt that the video and activities were effective in shaping how they thought about and approached teamwork. Students also noted that addressing the idea of enhancing respectful, equitable teamwork should continue to be a part of the course in the future.

Introduction

Women and minorities continue to be underrepresented in the field of engineering. According to the U.S. Bureau of Labor Statistics, 16% of engineers in the United States are women, 6.6% are Black or African American and 10.3% are Hispanic or Latino [1]. Although these divides are often highlighted in the workforce, the lack of diversity in engineering is seen much earlier in STEM classrooms. Students from marginalized communities are often underrepresented in science and engineering courses beginning in high schools and universities. This disparity of representation in education, specifically in engineering universities, can make it challenging to create a diverse workforce of engineers for a variety of reasons [2].

Engineering courses heavily emphasize collaboration. Because of this, students are often assigned groups to work on projects throughout their engineering careers [3]. Respectful teamwork can motivate, empower, and encourage students from all backgrounds to persist through challenges, and to continue pursuing engineering [4]. However, when teamwork and collaboration is less respectful or inequitable, individuals (often women, racial minorities, members of the LGBTQ community, people with disabilities, etc.) may be discouraged to

continue studying engineering due to the working environment [4]. Therefore, it is imperative that early engineering classes foster inclusive and equitable standards of teamwork to ensure students of all backgrounds feel respected in academic collaboration. An environment of respect and inclusion is beneficial not only to the individuals in the team but also to the team as a whole. Teams of engineers that come from diverse backgrounds can perform better on technical tasks than a team of more skilled engineers [5]. A diverse array of ideas allows teams to come up with creative solutions and unique approaches to problems that many homogenous teams will struggle to come up with. Actively addressing the ideas of teamwork, diversity, and inclusion in various ways can help create an environment that can improve how teams function and how individuals thrive [6]-[10].

Project Approach

To address the issue of inequitable teamwork and encourage students to collaborate respectfully, two undergraduate students who had taken the first-year design course in the previous year used both research and personal experience from the class to develop a video and three activities (a communication game, a teamwork and collaboration activity, and a reflection seminar) for new students to participate in. These materials were piloted in two of the eight sections of the course during the Fall 2022 semester.

The Video

The 7-minute video created by the students discusses various topics. The two students first introduce themselves, explaining some motivation behind creating the video and activities, as well as a few personal details regarding their areas of study and interests in engineering. Then, they define diversity, equity, and inclusion as it would later be referenced and discussed in the activities created. The students emphasize the differences between equity and equality in this segment of the video, and briefly connect the ideas of diversity, equity, and inclusion to teamwork in the first-year design course. They discuss specific types of inequality in engineering, highlighting gender and discrimination.

As students that had already taken the class, they then emphasize ideas they thought were important for equitable and respectful teamwork. One student shares her personal experiences in engineering and how coming into the class with little engineering background and in the minority of women felt intimidating for a variety of reasons. She discusses her frustration when interacting with disrespectful or condescending peers who had more engineering experiences before the course. The students then segue into how it is important to recognize varying levels of experience and different backgrounds when working with new team members.

In the last part of the video, the students give an overview of what each activity will highlight: respectful teaching, awareness of varying engineering experiences, and finally a discussion and reflection on the activities, video, and the topics that have been discussed.

The Activities

The first activity focuses on the idea of respectful teaching and communication. In a first-year design course in which members of the project team come in with different backgrounds, skills, and experiences, it is quite common that some team members will find themselves in a position to teach or explain things to other members of the team. This activity tries to convey the message that in order to teach effectively and move the team to its desired end goal, communication should be clear and avoid condescension. In each round of this activity, a different team member silently reads a short sentence (for example, "The laser cutter is too hot") and then must communicate that sentence to the other team members with some restrictions (such as not using any of the words in the sentence and not acting anything out). Throughout the various rounds of the activity, there will be times in which a given individual knows information that the rest of the group does not know and other times in which the individual must "learn" from groupmates.

The second activity focuses on the idea of collaboration. This activity emphasizes that different team members often have different strengths and combining the contributions from all team members will often lead to a much better final product than is possible based on the contributions of only a single team member. The activity is a modified version of the classic egg drop challenge, in which groups try to build a device that will protect an egg from cracking when it is dropped from a substantial height. The twist in this version of the activity is that before the activity begins, each individual must choose one material from the available materials. Early on in the activity, each individual is only allowed to use their selected material. Later on in the activity, the group is to come together to make use of all of the selected materials to build a final device that can take advantage of the strengths of the various materials.

The third activity provides an opportunity for reflection and discussion regarding the previous items (the video and the first two activities). Students are asked to consider several questions in advance of a class discussion. This activity encourages students to continue thinking about how to enhance respectful, equitable teamwork throughout the course and to consider how they can practically incorporate the insights gained and lessons learned as the course moves forward.

The full instructions for the three activities are provided in Appendix A.

Implementation in Class

The first-year design course at Duke University typically has about 350 students in the Fall semester, spread across multiple sections. The video and activities described above were developed after the course's schedule for the Fall 2022 semester had already been set and only limited class time was available for new activities, so a modified version of these activities was tried in two sections of the course. These two sections each had between 40 and 50 students, which is typical for most sections of the course. The central aspect of the course is a semester-long, client-based, hands-on project in which groups of students (typically four or five students) work through various aspects of the engineering design process. Teams work together to understand the problem and context, develop design criteria, brainstorm solutions, select a

solution, iteratively prototype and test solutions, and also communicate through written technical memos, oral presentations, and a poster presentation.

Project teams were formed by the end of the first week of the semester. Students were then asked to watch the video before the start of the second week of the semester. During that week, the last 10 to 15 minutes of the three class meetings for each section were reserved for the activities described above.

The first activity was run basically as intended except that the time for each round was shortened to 60 seconds and only a few rounds were performed. As a result, most but not all students had an opportunity to play the role of explainer/teacher. Shortening the time limit per round to one minute did not appear to negatively affect the activity.

Due to time restrictions, the second activity was run as a thought experiment rather than as a hands-on activity. Students were still instructed to select one of the available materials and then to individually think about how they would use only that material to build an egg drop device. After sharing their ideas with their groups, they were then instructed to think of how they could use all of the materials selected by the group members to build a single egg drop device. This modification to the activity allowed students to still think about collaboration and combining contributions of various group members, even though it did not include a hands-on building aspect.

The third activity, the class discussion, was run as originally intended.

Results and Discussion

In the two weeks following the in-class implementation described above, students were asked to complete a brief survey to provide feedback on the video and activities to assess their potential value, including whether they should be used in future iterations of the course. The survey included a mix of free-response questions and questions using a Likert-type scale. The survey questions are provided in Appendix B.

Of the 89 students in the two sections, 53 submitted a response to the survey. The five questions using a Likert-type scale assessed the effectiveness of the video and the three activities and also asked whether addressing the topic of respectful, equitable teamwork should be continued in future iterations of the course. A total of 47 students responded to these questions. The results for these questions are shown in Table 1.

A large majority of students who responded to the survey felt that the video and various activities were helpful and effective in shaping how they thought about and approached teamwork. Specifically, 77% agreed or strongly agreed that the video was helpful and effective, 79% agreed or strongly agreed that the first activity was helpful and effective, 68% agreed or strongly agreed that the second activity was helpful and effective, and 66% agreed or strongly agreed that the third activity was helpful and effective. Finally, 83% agreed or strongly agreed that addressing the idea of enhancing respectful, equitable teamwork should continue to be a part of the course in the future.

Table 1. Survey Results for Enhancing Respectful, Equitable Teamwork Portion of Course

Question	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
The video was helpful and effective	0% (0/47)	13% (6/47)	11% (5/47)	64% (30/47)	13% (6/47)
Activity #1 was helpful and effective	2% (1/47)	6% (3/47)	13% (6/47)	62% (29/47)	17% (8/47)
Activity #2 was helpful and effective	0% (0/47)	15% (7/47)	17% (8/47)	51% (24/47)	17% (8/47)
Activity #3 was helpful and effective	0% (0/47)	13% (6/47)	21% (10/47)	51% (24/47)	15% (7/47)
Addressing these ideas should continue to be a part of the course in the future	0% (0/47)	4% (2/47)	13% (6/47)	34% (16/47)	49% (23/47)

The responses to the open-ended questions reflected a wide range of generally positive feelings. Many found value in simply having an opportunity to interact with their new groupmates (for example, *"I think the best part about it was that I was able to get to know my team mates better. It wasn't necessarily the content of the activities that I enjoyed the most but it was the conversations with our team mates."*). Others indicated a possibly more profound impact (for example, *"The first two activities were very paradigm shifting. The paper slips activity made me focus on how I came across to others, and the egg drop thought experiment reassured me that my perspective would add something to a group discussion."*). The main suggestions for improvement were to make this portion of the course more active (for example, several people suggested actually building the egg drop device rather than just doing a thought experiment) and to spend more time on the discussions and activities (though, several people also suggested shortening this portion of the class). Finally, at least one response explicitly suggests that there is value in these activities particularly for underrepresented students: *"As someone from an underrepresented group in engineering, I feel seen in the development and execution of this activity. Thank you for creating/including this!"*

Conclusions and Future Steps

Overall, the video and activities show promise in terms of how they integrate into the first-year design course and in terms of bringing the idea of respectful, equitable teamwork to the forefront of students' minds. Potential next steps include expanding the use of these materials throughout all sections of the course, considering whether or not the second activity (the collaboration activity) effectively serves its purpose as implemented during the pilot, and more formally evaluating the effects of the video and resources.

The two sections that the activities were piloted in were both taught by an instructor who was involved in the development of these resources. Expanding to all sections of the course would

require having instructors who were not involved in the development take charge of the implementation in their sections. With clear instructions, we anticipate that these activities could be implemented fairly easily by a wide range instructors, but areas of emphasis in terms of class discussions may vary from section to section. In future years, the video would likely need to be updated as well. Part of the value of the video is that it was recorded by students who had recently taken the course and could share some of their personal experiences (as indicated by one survey response: *"I really enjoyed the video made by EGR 101 students last year because I found it incredibly valuable to hear the perspectives of people who have had experiences that I am currently encountering."*). The video may lose some of its effectiveness as it ages and the experience of the students in the videos seems farther away from that of current students.

The collaboration activity was designed to be a hands-on building activity but was piloted as a thought experiment. Although the implemented version brought up the main desired points regarding collaboration and the value of contributions from all team members, it is possible that implementing it as a hands-on activity would bring additional value. A hands-on activity would require additional planning, resources, class time, and clean-up but may be worth the effort, especially in the context of a first-year engineering course that does emphasize hands-on activities and prototyping. Therefore, this is a step that will be considered in the future.

Although the survey results suggest that the video and activities had value, the actual effect on teamwork was not formally measured. Measuring the effect conclusively may be challenging due to the many factors that affect how a team functions (the members of the team, the classroom environment created by the instructors and teaching assistants, the details of the specific projects being worked on, etc). However, by introducing a survey at the end of the course regarding students' experiences with teamwork and by increasing the number of groups being studied (through expanding the use of these activities to all sections), the potential exists for collecting meaningful data. This expansion also provides the possibility for comparing different circumstances (for example, using the thought experiment versus the hands-on implementation for the collaboration activity) across different sections. Thus, a future focus of this work can be to assess the effect of these resources and activities on student experiences in the course.

Finally, although an initial motivation for this project was to improve the teamwork experiences of underrepresented engineering students, there is reason to believe that positive effects of this work could extend to all students. A further area of study could be an investigation into how these resources and activities affect various demographic groups differently.

Acknowledgment

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Appendix A

Activity 1: COMMUNICATION GAME

Introduction : For our first activity, you will be playing a communication game with your group that highlights the idea of ***Respectful Teaching.*** Please keep in mind the following:

- Your teammates will not know exactly what you are trying to communicate to them. When communicating and speaking, make sure to **stay aware of their lack of knowledge or understanding.** It will help you communicate more effectively.
- How you speak and communicate to someone is just as important (if not more) than the information you convey. **Try not to be condescending in your communication and tone of voice.**
- It can get frustrating when ideas are lost in miscommunication. This is ok! The point of the game is to highlight how challenging communication of ideas can be.
- Think about how **clear and respectful communication** leads to more effective teaching.

Instructions : HOW TO PLAY?

1. Each member should draw from the pile of notecards. Read your notecard and hide it from your other teammates.
2. The member with the notecard with a 1 in the right corner will begin the game.
    1. This member should do the following:
        1. Start the timer
        2. Begin explaining the sentence on the card in the best way you can. You CANNOT USE ANY OF THE WORDS ON THE CARD TO DESCRIBE the sentence. You also cannot act anything out. You may only use words.
        3. Continue explaining and trying to communicate in the best way possible to your teammates. Other teammates should continuously be guessing and trying to collectively think of the sentence on the card.
        4. When the 90 second timer runs out, the guessing members must together agree on their final guess and share it with the teaching member.
        5. Take 30 seconds to debrief any miscommunications. What went well? What didn't?
        6. If the team guessed correctly, the whole team gets a point.
3. Repeat step 2 with all members getting the chance to teach their card to the rest of the group.
4. Sum your points and divide by the number of members in your group. This is your final score.

Class Discussion: *What went well? What was most challenging about the game? Did you find it easier to listen to members who were respectful? Debrief. Each team should select one member to be prepared to share one takeaway with the class.*

Activity 1 sentences (can print and cut out, just need to ensure each group has a mix of 4 different sentences or however many sentences as there are people in the group)

The 3D printer needs filament. (1)

The laser cutter is too hot. (2)

The soldering iron is broken. (3)

There is not enough wood to make a box. (4)

The box cutter is under the table. (5)

The drill is upside down. (6)

I need to upload my work to trello (7)

My water bottle is empty (8)

Your computer is out of battery (9)

Where is the Foundry? (10)

Activity 2: TEAMWORK & COLLABORATION GAME

Introduction: For the second activity, we will be working as teams to see which teams can work together to effectively solve an engineering challenge. When working please remember to:

- Include everyone within your team and to be respectful of everyone's ideas. Don't shoot someone else's idea down because you don't agree with it - incorporate parts of their idea to make the best possible solution.
- In order to be successful within the short time limit, everyone on the team has to work together on different parts of the project.

Project:

- Teams will have 25 minutes to design a device which protects an egg from a long fall (similar to the classic egg drop). After this time is over, teams will weigh their builds and head up above the Pod or Foundry and drop their eggs. The team whose egg survives and contraption weighs the least will win!
- However, before teams can start building, each team member must select an item from the Pod/Foundry and they are only allowed to build using that item (ex. tape, pipecleaner, straw). Everyone needs to work together to combine the strengths of their items in a working egg drop.

Instructions:

1. For the first 5 minutes, each team member will choose an item and then brainstorm how that item can be used to make an effective egg drop. Think of all the different ways each item can be used. Be creative! (no building during this time)
2. For the next 5 min, teams will then come together and combine their ideas to create a solution. When starting to build, try to use only your material and no one else's.
3. After 15 minutes all work will stop on the egg drops and teams will weigh their projects and then head up to drop test them out!
4. After everything is done please make sure to clean up your workstation and put all materials used away in their proper place.

Team Reflection: What went well with this project? What went poorly? If your egg drop failed what were the points of failure? If it succeeded how could you have made it weigh less? How did the constraints of this challenge affect the end result?

Activity 3: SEMINAR TO REFLECT & DISCUSS

Introduction

Pre-Work: Please answer the following questions below. No one will be reading these responses; this is simply for you to prepare your thoughts for the class discussion we will be having regarding our activities this week on how to enhance respectful, equitable teamwork in First-Year Design. We will discuss these questions as a class tomorrow.

1. Why do you think it is so important to consider this idea of respectful teaching and communication throughout this first-year design class, and throughout your education and career as an engineer?
    a. Is it hard to learn when someone is being condescending? Would it encourage you to continue asking questions if they are not being acknowledged respectfully? Think back to Activity 1.

2. How can we ensure that all voices and ideas are both heard and respected when working in teams this year given some of the statistics below and ideas we have talked about this week?
    a. 36% of Duke undergraduate engineering consists of women, and the national average is even lower

3. What can you do to stay aware of the fact that we are all coming from different areas of expertise and opportunity? Each one of our experiences with engineering will vary; after Activity 2, do you think this is a good or bad thing? Why?

4. After this week, do you have a better idea of how to encourage respectful and equitable teamwork? Do you have any additional strategies you can think of that would help enhance this kind of teamwork?

5. If you do come across an instance where you feel disrespected or overlooked in your team, for whatever reason this may be, would you feel comfortable addressing it yourself or speaking with a TA/instructor?

Appendix B

Survey Instructions and Questions

Please provide feedback regarding the Enhancing Respectful, Equitable Teamwork portion of the course. This portion of the course had 4 components during the second week of class: (1) a video that you watched during the weekend, (2) an activity that we did on Monday (with the slips of paper with sentences), (3) an activity that we did on Tuesday (the thought experiment with the egg drop device), and (4) a final wrap-up discussion that we did on Friday. Please take 10-15 minutes to truly think about your experience and provide meaningful feedback before next week.

1. The video was helpful and effective in shaping how I think about and approach teamwork.
    - Strongly Disagree
    - Disagree
    - Undecided
    - Agree
    - Strongly Agree

2. Activity #1 (the communication game with slips of paper with sentences on them) was helpful and effective in shaping how I think about and approach teamwork.
    - Strongly Disagree
    - Disagree
    - Undecided
    - Agree
    - Strongly Agree

3. Activity #2 (the collaboration game where we did a thought experiment about an egg drop device) was helpful and effective in shaping how I think about and approach teamwork.
    - Strongly Disagree
    - Disagree
    - Undecided
    - Agree
    - Strongly Agree

4. Activity #3 (the reflection questions and wrap-up discussion) was helpful and effective in shaping how I think about and approach teamwork.
    - Strongly Disagree
    - Disagree
    - Undecided
    - Agree
    - Strongly Agree

5. What was good/worked well about the Enhancing Respectful, Equitable Teamwork portion of class?

6. What could be improved about the Enhancing Respectful, Equitable Teamwork portion of class?

7. Addressing the idea of Enhancing Respectful, Equitable Teamwork should continue to be a part of the course in the future.
    - Strongly Disagree
    - Disagree
    - Undecided
    - Agree
    - Strongly Agree

8. Please provide any additional comments/feedback/thoughts here: