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Characterizing Student Work while Solving Ill-Defined Statics Problems in Groups

Max Magee, University at Buffalo, The State University of New York

Max Magee is an undergraduate research assistant in the Department of Engineering Education at the University at Buffalo. He is majoring in Aerospace Engineering and minoring in Law and Mathematics and set to graduate in May 2023. After graduation, Max plans on seeking employment in the Aerospace field, preferably working with space craft.

Dr. Jessica Swenson, University at Buffalo, The State University of New York

Jessica Swenson is an Assistant Professor at the University at Buffalo. She was awarded her doctorate and masters from Tufts University in mechanical engineering and STEM education respectively, and completed postdoctoral work at the University of Michigan. Her current research involves examining different types of homework problems in undergraduate engineering science courses, the intersection of affect and engineering identity, and improving the teaching of engineering courses.

Full Paper: Characterizing Student Work while Solving Ill-defined Statics Problems in Groups

Abstract

Engineering problems are ill-defined, require assumptions, and have multiple unique solutions. Although most industry engineers solve ill-defined problems in groups, students typically only practice this in engineering design courses. Our research aims to expand these experiences to engineering science courses.

Currently, most engineering science courses assign 'classic' textbook problems, where they are given certain physical parameters of a system, and are told to calculate an unknown value. Ill-defined modeling problems provide students with more opportunities to utilize engineering judgment when compared to traditional textbook problems, and when these problems are solved in a group setting, it is both a better representation of how engineering is performed in the industry, and can help students better understand the class concepts. This paper examines groups of students solving an ill-defined modeling task that asks students to design a portable pool lift. When working in a group, students have the opportunity to help each other understand what was taught in class, along with the ability to push back on other students' ideas. This will prepare students for their future career, lead to knowledge creation and help solidify concepts taught in class.

This full paper analyzes data (approximately 15.5 hours) that was collected in the form of recordings of zoom meetings of two groups that were tasked with solving an ill-defined modeling problem in a second year statics course. Using comparative coding, we categorized how students spent time when working in their group. Results show students alternate between negotiating tasks, comparing assumptions, and aiding each other in understanding course concepts. Implications of this work include forming a better understanding of how students make decisions, judgments and build knowledge when working together on an ill-defined modeling problem. Similarly, the results may assist professors in iterating on assignment design to further engage students in knowledge creating and engineering judgment practices.

Introduction

Industry engineers are often tasked with solving ill-defined problems in a group with fellow engineers [1], [2]. Although engineering curriculums are constructed to prepare students for industry, there is a documented disconnect between the ways that many students currently solve engineering problems in their classes, and how they are expected to solve problems if they pursue a career in engineering [1]–[3]. Engineering science courses typically assign closed ended problems which have one answer and one method of finding a solution, and are expected to be completed individually, in contrast to the open endedness of real world problems which are solved through collaboration and fusion of engineering judgment and conceptual knowledge to create a solution, rather than find the “accepted” one. Engineering science courses (e.g. thermodynamics, statics, and dynamics) serve to provide students with the tools to solve engineering problems in the form of physics and mathematics knowledge, although they typically do not provide students the ability to utilize these tools with an accurate representation of how they will apply them in industry. Many students are not provided the environment to utilize the knowledge they acquire in engineering science courses until two years later in their senior design class. To assist in bridging the gap between academia and industry, our research team has curated and administered open-ended modeling problems (OEMPs) for engineering science courses to allow students to engage in collaborative knowledge creation and experience a more accurate representation of how engineers in industry solve problems.

The Accreditation Board for Engineering and Technology (ABET) sets forth quality standards for engineering curricula to ensure that students that are enrolled in an ABET accredited program are well equipped for industry. Open-ended problems solved in a group setting have the ability to satisfy many ABET outcomes at once, most notably outcomes one, two and five. The first outcome, “an ability to formulate, and solve complex engineering problems,” students don’t usually engage in until their capstone design course, although an OEMP will expose students to complex engineering problems that are solvable with their level of engineering and applied physics knowledge. The second ABET outcome, “an ability to apply engineering design to produce solutions that meet specified needs” including socio technical factors, is difficult to fulfill with closed ended problems, because there is no one correct solution for any engineering problem when accounting for the myriad of considerations that arise from incorporating cultural, social, environmental or economic factors into an engineering solution. ABET outcome 5, “an ability to function effectively on a team” is also often not satisfied in many engineering science courses prior to a senior design course, because most assignments are assigned as individual work.

A typical homework problem provides students with a simplified model of a system and asks them to find certain values by using the equations they are provided with in class, and group work on these problems are often discouraged if not explicitly prohibited. Instead, to solve an OEMP, students tackle a complex real life design problem by engaging in engineering judgment to simplify the model as they see fit, and then apply the canonical mathematical models they were taught in their engineering science courses to guide their design decisions in a group setting and reflect on their answers. Previous research has focused on engineering students working together within designated design courses, but little is known about how students work together in a group to solve a problem in an engineering science course.

This full research paper serves as our first attempt to answer the questions:

1) How do undergraduate engineering student teams solve an open-ended statics problem?
2) How does solving these problems contribute to building professional engineering skills?

Background

One of the main activities of an engineering students' weekly activity is completing homework problems, problem sets, or working on projects. While a significant amount of research has examined how students work together to complete design projects and learn design [4]–[6] few studies have examined students solving homework problems or projects in engineering science courses, an understudied area of research [7]. Lord and Chen [8] have called for more research into the "middle years" of the engineering degree, where students must take a number of disconnected courses with high levels of mathematical problem solving that are not highly engaging for students.

Douglas and colleagues have answered this call by examining the types of problems in typical textbooks [9], students' use of textbooks during problem solving [10], students' beliefs about problem solving [11], and students' approaches to solving open-ended problems [3]. Their research found students use textbooks as a source for specific pieces of information such as equations and material properties, and to understand the steps of how to solve a problem by working backward through example problems [10]. In another study [3], when students were asked to solve open-ended problems, researchers found students were overwhelmed and uncertain, became fixated on different parts of the problem solving process that inhibited progress, or followed very linear and systematic processes. In short, despite these students being seniors, they struggled with the open-endedness of the problem and had difficulty solving the problems well. Douglas and colleagues' research have further uncovered gaps in students' learning problem solving in engineering courses and show there is clearly more to be done. We build on this work by examining groups working together on open-ended problems.

Discourse as Part of Learning

This paper also builds on research in science and engineering education that examines student talk [12]–[15]. Science education researchers have long discussed student discussion as being a mechanism for sense making or figuring something out [13], and "essential to the way that scientists and engineers construct knowledge" (p.189) [14]. Berland & Riser [12] discuss how constructing arguments with others through the steps of making sense, articulating, and persuading others not only engages students in authentic disciplinary practices but also in a mechanism for learning science. Odden and Russ [14], in their paper clarifying sense making, explain further that constructing arguments is in service of collaboratively discussing something to figure it out. Engineering researchers have similarly examined senior design teams discussions as they work on simulation of designing a chemical vapor deposition process [16]. The research team looked at how the group's talk was either directed at completing the task assigned by the instructor (task production) or at making meaning or forming an understanding (knowledge construction). Similarly, Kittleson and Southerland [15] examined how a mechanical engineering senior design time constructed knowledge together about a car's window defrosting system. Swenson [17], [18] utilized the same framework to analyze three groups of students solving fluid mechanics homework problems, and found students spent the majority of time engaged in task production. This project continues this research in examining the kinds of talk students are engaged in when solving a novel, open-ended statics project. We see this work as further building our knowledge in understanding how students may or may not be gaining knowledge while performing assigned tasks.

Coding Engineering Activity

This paper uses methods of coding activity that have been historically used to capture problem solving processes as individuals [5], [19], [20] or in teams [16]–[18], [21], [22]. Atman and colleagues [5], [19] used a think-aloud protocol to capture the design process of freshman, seniors, and experts and code their thinking utterance by utterance. These analyses also produced visualizations of each design process that highlighted differences between levels of expertise, such as experts spending more time problem scoping than seniors, who in turn spent more time scoping than freshman.

Wendell [21] expanded on the list of Atman's activities as she moved from examining individuals to groups. She added "Design-Related Conversational Moves" (p.5) that include revoicing, request, agreement, disagreement, and instructor's intent, highlighting discourse as a necessary part of group work. The need for these conversational moves was confirmed by Swenson, Portsmore, and Danahy [22] after analyzing first-year design students building robots. This paper takes up a similar practice coding segments of time to understand how engineering teams went about solving semester-long statics problems.

Methodology

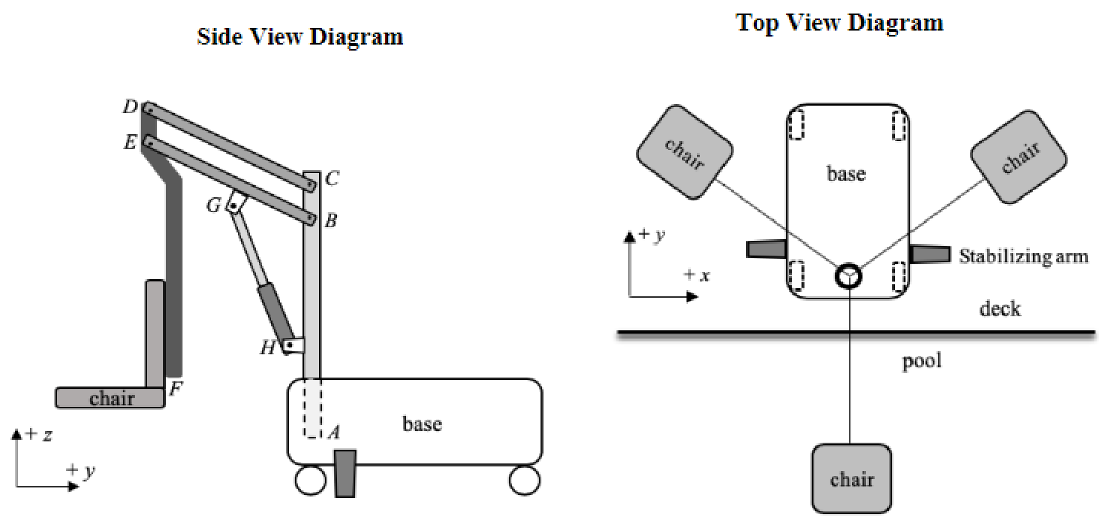


Figure 1. Diagrams of the Pool Lift Provided to the Students

This study was performed at a large, public university in the northeastern United States. Second year engineering students enrolled in statics were assigned an ill-defined problem involving designing a portable pool lift with a group of 4-5 other students. The portable pool lift problem requires students to apply what they were taught in class to a real life design problem, and engages students in engineering judgements. The project spanned the majority of the semester divided into six individual analyses each followed by a group compilation building of the individual assignments. Groups were randomly generated, with four to five students assigned to work together. Each of the individual pieces was assigned after learning the relevant material, after learning new material, an individual section of the project that utilized the material was assigned, and the following week a group section was assigned that built off of what the students worked on individually. The individual and group assignments required students to create free body diagrams, calculate diameters and choose materials   Due to the COVID-19 pandemic, all group meetings were administered over Zoom, which allowed for the meetings of students who consented to participate in the research to be recorded and uploaded to a cloud server. All students who were assigned the portable pool lift project were invited to participate in this study. If all students of a group consented, their group videos were added to the data corpus by the research team for the purpose of this study. Each member of the group was given $5 for each part of the project their group recorded and submitted, with a total possible of $30 per student.

Table 1. Pool Lift Problem Assignments

Assignment	Tasks
Part I	• Choose operational heights • Create an equation that relates lengths of members to operational height. • Choose lengths of members • Choose recommended weight limit
Part II	• Determine angles on the diagram that results in the worst case tipping scenario. • Perform equilibrium analysis to select a preliminary weight of the base and center of gravity location. • Choose a 3 dimensional shape for the counterweight
Part III	• Draw Free Body Diagrams (FBDs) required to solve for six joint reactions. • Write equilibrium equations for the FBDs. • Use a coding language or spreadsheet to solve for the joint reaction forces and list in a table.
Part IV	• Discuss how to model a support at a point. • Create shear force and bending moment diagram for the vertical member of the pool lift. • Determine the maximum shear force and bending moment location and magnitude
Part V	• Choose what values to use for bending moment and centroidal axis to the point of interest for maximum stress analysis. • Using maximum stress equations, choose a material and diameter for the vertical member of the pool lift. • Determine relationship between average shear stress and pin radius for certain joints. • Using maximum stress equations, choose a material and diameter for pins. • Given the maximum operating pressure of the hydraulic piston, choose a diameter of the cylinder.
Part VI	• Compile the work done in the previous 5 parts into a comprehensive final report that summarizes design decisions and the mathematical models used to guide them.

Data Analysis

Table 2. Data Corpus of Recorded Team Videos

Group A		Group B	
Name of Video	Time (Minutes)	Name of Video	Time (Minutes)
Part 1 Meeting #1	52	Part 1 Meeting #1	131
Part 1 Meeting #2	73	Part 1 Meeting #2	56
Part 3 Meeting #1	72	Part 2 Meeting #1	173
Part 4 Meeting #1	46	Part 2 Meeting #2	44
Part 5 Meeting #1	72	Part 3 Meeting #1	135
Final Report Meeting #1	16	Part 4 Meeting #1	79
		Part 5 Meeting #1	23
Group Total	331	Group Total	641
Total Duration of 13 of Videos		972 minutes (16.2 hours)	

Once having received all data submissions, following the end of the semester, the videos were analyzed through watching and breaking down each video into activity segments. These summaries, divided by time stamps, were broken up based on multi-model analysis of the group's meeting. An example of a summary is shown below in Table 3.

Table 3: Example of an activity segment.

Time Start	Time End	Summary
11:53	13:41	Students compare maximum and minimum heights that were determined during the individual portion. One student says she chose her heights based on comfort for the user because they are in a wheelchair. Another student says he found ADA requirements and used them in guiding his answer.

This process was repeated for both of the participating groups across 13 recorded videos, totaling 16.2 hours of collected data. Upon further analysis of this data, a coding scheme was produced by Magee (the first author) using a constant comparative method approach.

To begin, Magee viewed a recorded meeting from two separate groups (totaling 182 minutes) and open-coded the data, noting timestamps and what actions the group was engaged in. The first author noted that both Group A and Group B spent a significant portion of the video, 34% and 74% respectively, in silence. These long silences were not included in the written summaries and thus were not reflected in the coding scheme. From the data collected in this step, an initial draft of the coding scheme was created. The initial draft was shared with the third author, who asked questions about students' behaviors and helped refine definitions, which Magee once again applied to a new video. Considering the third author's input and firsthand experience using the codebook, the first author modified the codebook by refining some definitions, as well as adding two new codes, shown in Table 4.

To establish reliability in this coding scheme, the first and third author worked together through an iterative approach to finalize the code book, aiming for 80% similarity between their codes. The third author was first trained on the codebook, and worked with Magee to review data that was already coded, becoming familiar with the definitions and applications. The third author was then given the updated coding scheme along with a copy of time segmented data from a different video recording. The third author used these components to code through the data using their own interpretation of the code book. The first and third authors further compared their coded data finding only 71% similarity between their results. Given disagreement, the first author further refined the code book. The first and third authors performed another iteration of coding. While comparing their results, it was found their similarity on average was only 63%. Magee made a final change to the code book as seen in Table 4. The first and third authors then took a final pass at coding, using three hours' worth of broken-down data, and compared their results. This time, the first and third author found on average 83% similarity between their code, establishing a reliable coding scheme. Having finalized our coding scheme, Magee then was able to segment and code through the remaining video data.

In total, there were 279 segmented summaries between both groups, which encompassed 31.6% of the recorded time. The remaining 68.4% of time that students spent in their recorded Zoom meetings was spent not working on the project in silence. Of the 279 written summaries, 254 of them (91%), which accounts for 30.3% of recorded time, were able to be categorized under the final version of the codebook seen in Table 4.

Table 4: Codebook

Codebook			
Code		Definition	Examples
Group Planning (GP)		Students plan future events; such as when they can meet next or split up tasks.	"What time are you guys free later this week?" "Which one of us is going to use their drawing? I can redo mine in CAD"
Clarifying Assignment Confusion (CAC)		Students talk about uncertainty with the non technical parts of the project, such as the deliverables or grading.	"Do we have to add in the dimensions for this portion of the assignment? The wording is vague." "I wonder if she [grader] didn't grade our equation on purpose so we can decide who has the right one."
Working on explicit questions (WEQ)		Students work together to solve explicit parts of the project. Such as "make shear force diagrams" or "choose values for lengths".	"So next we need to make the shear force diagrams, so draw an axis." "Let's start with #1, and choose a material for the pins."
Sharing or Comparing Individual Assumptions (SCIA)		Students share the assumptions they made during the individual portion of the assignment.	"I looked at my door hinges and said those looked like 5 inches long, so I chose 5" "I said the chair should support 500 pounds to be extra safe."
Creating or Modifying Group Assumptions (CMGA)		Student's make or modify assumptions as a group of two or more.	"We should measure the backs of the chairs we are sitting in, in order to gauge the dimensions of a normal chair." "We should take into consideration the divot at the

			top, we should look up average torso length to make sure the user's head doesn't hit it."
Disagreeing (DI)		Two or more group members disagree on an assumption, numerical answer or method of solving. This requires back and forth, not just one student correcting another.	Student 1: "I think 12 inches is reasonable for member BC." Student 2: "That seems too large, 8 inches seems more reasonable." Student 1: "If it were less than 10 inches, it wouldn't satisfy our engineering requirements."
Expressing Confusion (EC)		Students voice uncertainty or confusion related to how to solve a task.	"It's hard to decide values because we don't have a pool lift, the more I think about it, the more I think we should really have a pool lift."
Sharing Answers (SA)		Students share their answers, from the individual portion, or found during the meeting. This includes when students correct each other on errors with no back-and-forth discussion.	Student 1: "I plugged it into my calculator and got a maximum moment of 23 ft-lbs"
Peer to Peer Aid (PPA)		Students help each other understand class concepts or technical project related questions.	Student 1: "Is the moment we chose about A in the correct direction?" Student 2: "It doesn't matter what direction we choose because all that would change with our final answer is make it negative."
Reflecting (RE)		Reflecting	"I got 15,000 lb-ft, which doesn't make sense" "I don't think I did this correctly."

Results and Discussion

Each recorded meeting contained long periods of time in which students were not talking or actively working toward finishing the project. These were not broken into activity segments, and were composed of times that students were doing other work, talking about the ongoing pandemic, or current events Group A spent an average of 48.2% of their time engaged in activities that helped them make progress on the assignment (all codes listed in Table 4 except “Group Planning” and “Clarifying Assignment Confusion”), in contrast to Group B, who spent 15.3% of their meeting time engaged in the same codes. For example, a meeting from Group A consisted of 19 minutes of silence (34% of the video), whereas when working on the same part of the project, Group B’s recorded meeting had 48 minutes of silence (86.26% of the video). Overall, students spent a large portion of their time together not engaged in codable activity (70%) including sitting in silence, or discussing non class topics, such as schedules and athletics.

Data across both groups totaling 16.2 hours was used to make the following table which shows the percentage of time and the unique number of times that students engaged in a code.

Table 5: Activity of Groups A and B

Code Name	Code Color	Total time (s)	Unique Times	% of Total Time	% of Coded Time
Group Planning		980	19	1.72%	5.69%
Clarifying Assignment Confusion		1,013	28	1.78%	5.88%
Working on Explicit Questions		3,223	31	5.67%	18.71%
Sharing or Comparing Individual Assumptions		618	9	1.09%	3.59%
Creating or Modifying Group Assumptions		2,635	31	4.64%	15.30%
Disagreeing		1,557	22	2.74%	9.04%
Expressing Confusion		877	26	1.54%	5.09%
Sharing Answers		3,395	50	5.97%	19.71%
Peer-to-Peer Aid		1,334	31	2.35%	7.75%
Reflecting		1,590	34	2.80%	9.23%

The most prevalent code, accounting for approximately 6% of students meeting time was “Sharing Answers." Over the course of 13 videos, students were uniquely engaged in sharing answers 50 times. This may be due to the scaffolding of the OEMP, where students weekly alternate between individual and group assignments, with the group assignments including and building off of the individual portion. When students are tasked with creating an equation or deciding a value as a group, they will share how they did it as an individual the week before. Approximately 18% of the time that students were engaged in “Sharing Answers”, they were sharing assumptions that they made during the individual portion of the assignment. The ability to share assumptions and the reasoning behind assumption making is a unique feature of OEMPs. As seen in Figures 3-6, “Sharing Answers” often served to engage students in other activities. 56% of the time, “Sharing Answers” would result in engaging students to participate in other codable activities such as “Disagreement” which is when students had conflicting answers or methods of solving. Students spent 2.74% of their time (9.04% of codeable time) as a group in disagreement, a pivotal part of the design process which students inherently can’t engage in without being in a group, and helps students practice constructive conflict which in turn will lead them to be able to better effectively function as a team as specified in ABET 5. Time spent for each instance of disagreement varied with the number of students who were participating in the discussion and what the disagreement was centered around, although the discourse always resulted in agreement. Other papers examining group discourse [21], [22] similarly found students disagreeing or agreeing with each other’s ideas.

The second most prevalent code was “Working on Explicit Questions,” where students worked as a group to complete the assignment. “Working on Explicit Questions” is when students worked together during the video to get the required deliverables for the assignment complete. For example, during part IV of the project, students were tasked with creating shear force and bending moment diagrams and the time they spent in drawing the diagrams was coded as “Working on Explicit Questions” because they were working toward the singular goal of finishing the project and there was little room for students to engage in knowledge creation activities such as assumption creation. Students spent 4.64% of their time, totalling 45 minutes working together across both teams to create necessary assumptions to make the problem solvable. Assumptions that students made include the water level in a pool, what size seat would be comfortable and safe for a user, what material to use when accounting for strength and cost, along with the maximum weight they should design the pool lift to support. These discussions show that the OEMP is leading students to engage behavior that satisfies ABET outcome 2. Creating assumptions as a group and talking about assumptions that they made individually are not activities that students typically engage in when solving a classic textbook problem which doesn’t require assumption creation to make it solvable like the OEMP does.

Students “Expressed Confusion” or asked questions to their group mates 26 unique times between both groups, accounting for 2.74% of recorded meeting time which would often (50% of the time) lead to students helping each other. Students would help each other understand different topics throughout the OEMP, from clarifying the given diagram and explaining how the lift physically operates, to teaching class concepts, such as the definition and engineering implications of a two force member. Research on student discourse [12]–[14], [18] demonstrates that the process of explaining phenomena to others helps both the person explaining and those listening to understand the concept better. Students in engineering science courses typically do not have the opportunity to engage in discourse due to the nature of homework problems typically being assigned as individual work and any collaboration being seen not as a way to reinforce class topics and prepare students for their future careers, but cheating.

"Group Planning" accounted for 1.72% of the total time the groups spent together, which included splitting up tasks and planning future meetings. Engaging in this activity provides students practice communicating with each other to establish goals and plan tasks, as they will be expected to in industry and as outlined in ABET outcome 5. Koretsky and Nolan [16] found a similar code when examining senior design teams planning and completing course assignments. Individually assigned problems do not encourage students to engage in this behavior, which will lead to them not having practice with working with others to create and stick to a schedule until their senior design course, which is only a year before they enter professional careers.

Comparing Group A and Group B
Two videos from each group that had the highest percent of coded time were chosen to create the following figures, which illustrate how students move through engaging with different codes as they progress through a portion of the OEMP. Each individual mark on the graphs represents 10 seconds of each activity.

Figure 2. Codebook Key

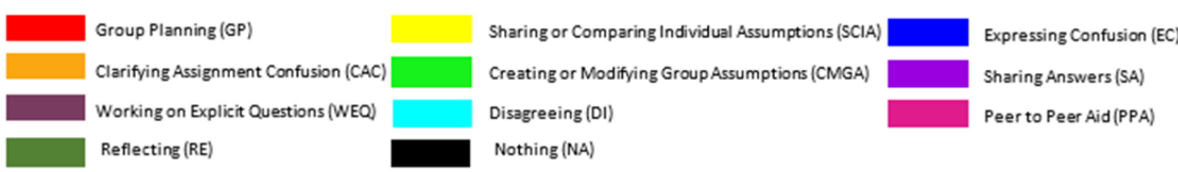


Figure 3. Group A Part 1 Meeting 1: Choosing lengths of different members of the lift and creating an equation that relates length of members to operational height.

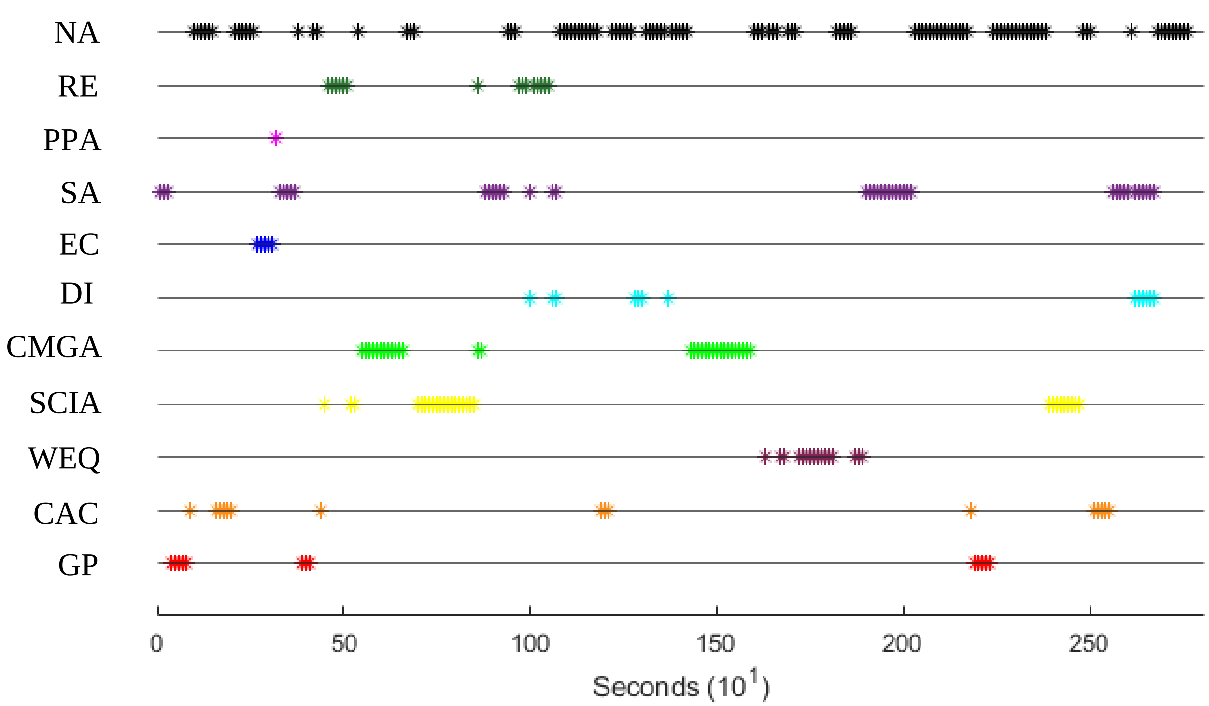


Figure 4. Group A Part 3 Meeting 1: Creating free body diagrams and equilibrium equations when the pool lift is at rest.

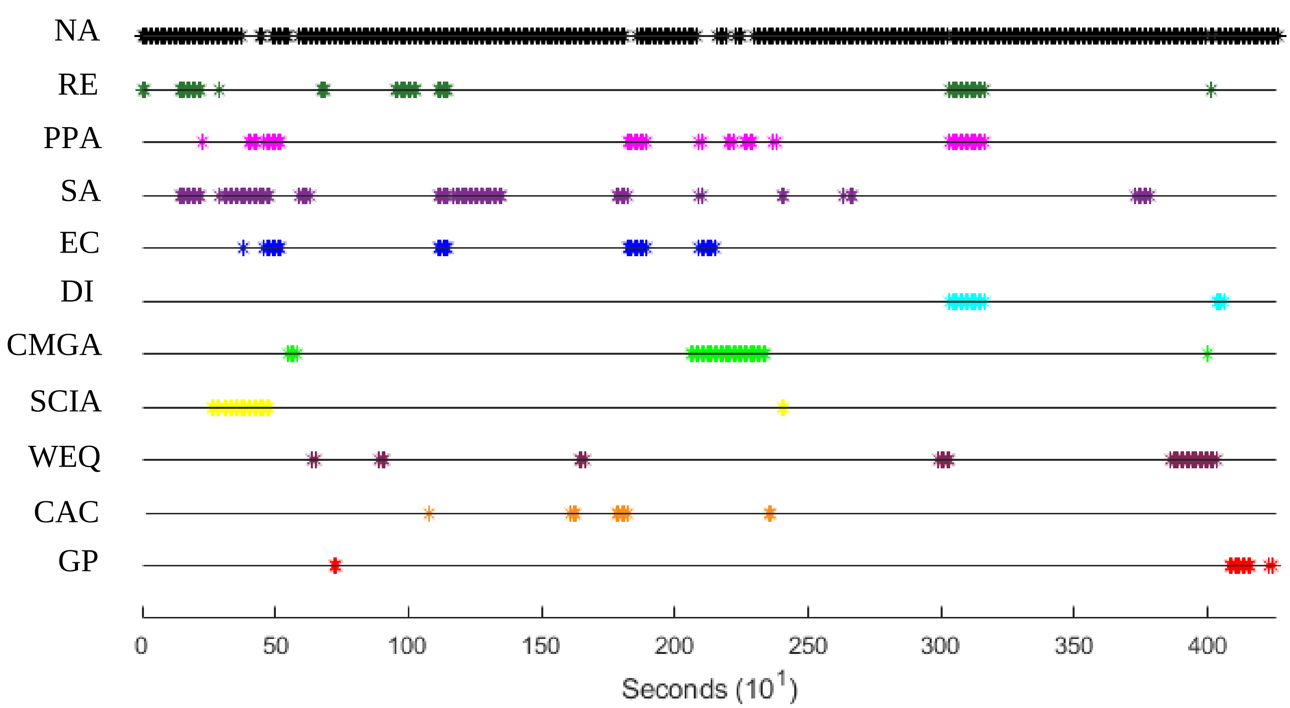


Figure 5. Group B Part 1 Meeting 1: Choosing lengths of different members of the lift and creating an equation that relates length of members to operational height.

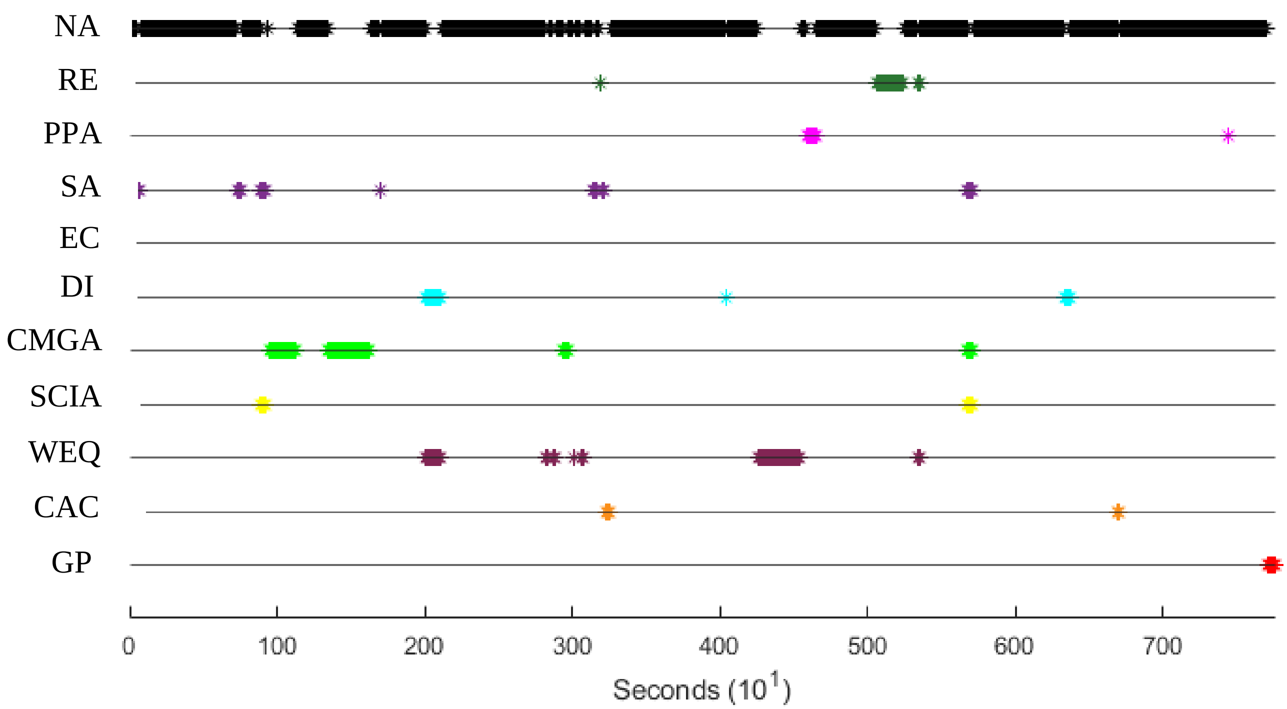
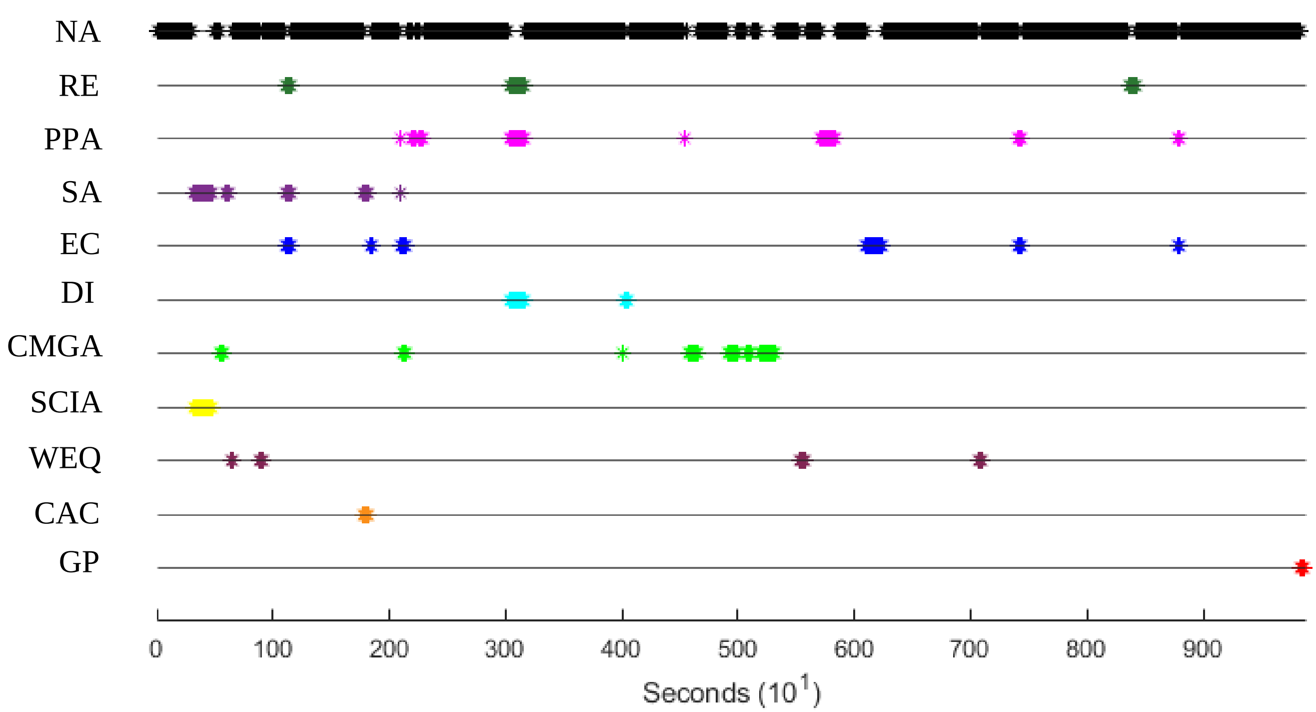


Figure 6. Group B Part 2 Meeting 1: Determining the worst-case tipping scenario and designing a counterweight system.



As seen in figures 3-6, Group A spent less time than Group B both in total, and in silence or off topic talk, as illustrated by the “NA” data set at the top of each figure.

Meetings would often end with students engaged in the “Group Planning” code because they would be discussing when they could meet next, or if they didn’t finish the assignment during their time, split up the remaining work to be done individually.

As stated in the previous section, “Sharing Answers” (SA, purple on Figures 3-6), would often serve to engage students in another code such as disagreement or peer to peer aid when a student would not agree with an answer, or asked for clarification about how to calculate an answer. Reflection would also sometimes result in disagreement, because one student may think the answer they arrived at is not reasonable, but another student may believe that their answer is appropriate.

The “Creating and Modifying Group Assumptions” (CMGA, bright green on Figures 3-6) and “Sharing or Comparing Individual Answers” (SCIA, yellow on Figures 3-6) would often appear together or right after each other because students would share the assumptions they made during the individual portion of the assignment before working together to establish the assumptions that they will all accept as true as they continue through the assignment. There were multiple unique instances of students making assumptions as a group throughout each video, because students would have to create an assumption as a group to make progress with the next part of the assignment.

Conclusions & Implications

Our analysis shows undergraduate engineering student teams collaboratively solve problems, sharing answers and engaging in debate to make decisions as a team. We also saw that working in groups means students take time to teach each other course content, and clarify and explain confusion within the problem. The amount of silence, especially by Group B, and off-topic talk was surprising to us. It seems these students preferred to work independently while in the same “room” together. We hypothesize one reason students may have engaged in so off-topic talk is this data was recorded during the Covid 19 pandemic and most of these students were isolated in their homes away from other students. These meetings may have been some of the only socializing they had with their peers.

We also see some evidence of students using discourse to build knowledge [13]–[15], by explaining pieces of the assignment or class concepts to each other. While some may also see our code ‘Disagreement’ might not be productive, research from science and engineering education have shown this is productive for learning [12], [17], [18].

From our analysis, we argue that giving the opportunity to engineering students to solve complex problems allows them to build professional engineering skills that are usually not developed in engineering science courses. It was observed that when students are working together on an OEMP, many of their actions are aligned with practices that ABET states as being beneficial to engineering students, most notably outcomes 1, 2, and 5. This leads us to conclude that OEMPs should continue to be administered in engineering science courses at universities to help bridge the gap between education and industry. At the university where this work takes place, students have encountered OEMPs in the follow-on course, dynamics, and there are plans to create and assign an OEMP in aerospace and mechanical engineering fluid mechanics this coming fall.

Further research can be done, applying the same open coding and validation process on students completing OEMPs in other classes throughout their college career, focusing on second and third year. While we encourage further research to examine student collaborative work, we do not suggest using this exact scheme for other sets of data. Our goals in this work were to best capture what our students were doing and utilizing this same scheme on other work may cause other research teams to miss interesting and important interactions. Therefore, we encourage other groups to also begin with open coding to capture the unique work their student groups are doing, for example students in their second year may engage in different levels of engineering practices that first/third/fourth year students don't and vice versa. This would allow our research team to track how students develop professional skills as they garner more experience solving complex open-ended problems as a group.

Our recommendation to professors who are employing OEMPs in their classroom is to continue doing so, because students who are assigned OEMPs engage in useful collaborative practices with each other. Furthermore, professors who are interested in assigning similar projects would find them useful in preparing students for their future careers.

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