

Peer and self-assessment of teamwork for students with accommodations in a project-based laboratory course.

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Paper from Practice: Peer and self-assessment of teamwork for students with accommodations in a project-based laboratory course.

Student accommodations for physical, psychological, or neurological disabilities commonly include extended testing time or a private testing room. However, these accommodations are less helpful in a project-based laboratory course with no exams. Moreover, neurodivergent traits related to time management, social interactions, organization, and producing written assignments may make group work contentious. A project-based lab course at Northeastern University has instructor-formed groups working for the entire term on six lab experiments and a term project. Four of the labs require group-written reports. These reports are accompanied by individually written team assessments where students estimate the percentage of work done by each group member and reflect on group function, what could be improved, and what the group struggled with. Team assessment assignments from 118 groups over three terms were examined using a mixed-methods approach. The difference between the highest- and lowest-rated team members on each team was used as a measure of teamwork, with higher differences indicating less agreement on individual team member performance. These differences were compared for teams that did and did not contain team members with formal accommodations. Additionally, open-ended responses from the team assessments were analyzed for patterns and common themes. Groups with students requiring accommodation had statistically larger differences between students for the first group lab report, but not the others. This result is reinforced by reported improvements in group function for many groups. Additional findings show that neurodiverse students tend to underestimate or overestimate the amount and quality of work they contribute to the team. Targeted intervention from the professor shows some promise of more rapid alignment of team members about teamwork. This work emphasizes the need to consider the support needed for disabled and neurodiverse engineering students.

Introduction

Students with physical, psychological, or neurological disabilities are entering higher education in increasing numbers. Although some may have had diagnoses since childhood, some disabilities are not detected until students reach college. Students with documented diagnoses may request accommodations to support their academic success. However, most accommodations are designed for individual tasks, leaving a gap in support for team-based coursework. These accommodations typically allow additional time on exams or assignments, reduced distractions, special format learning materials, or other aids to their learning. However, not all students want to disclose their disabilities for fear of stigma or being judged. Also, some students who need accommodations do not get them because they lack a formal diagnosis.

One activity common to engineering coursework is team-based projects and laboratory experiments. Students who are neurodivergent or contending with mental health conditions may find teamwork difficult, however, accommodations typically are not developed with teamwork support in mind. If a student with invisible disabilities struggles with their work, it only affects their grade. However, if this same student struggles with group work, the entire group's grade is affected. This can lead to additional social consequences as these students can develop an undeserved reputation as slackers. Inclusive teaching methods need to expand to include

scaffolding for teamwork. The literature review below will present what is known about the intersection of inclusive teaching, accommodations, and teamwork to build on this foundation using qualitative and quantitative data from the current study.

Author Positionality

I am a teaching professor at an R1 university in the Northeast of the United States. I was diagnosed with ADHD after age 40 and with autism at age 50. I have taught design and laboratory courses for more than 25 years and have performed engineering education research for that entire time. My interest in supporting students with invisible disabilities was initially sparked by my own sons' struggles in school with their learning issues. Subsequently, exploring my neurodiversity led me to connect with other neurodiverse faculty. Hearing that I was not the only person who struggled in college, graduate school, and beyond made me feel I could start to be my authentic self. This allowed me to connect with my neurodiverse students, learn from them, and challenge myself to optimize my classes for them.

Accommodations in Higher Education

The Americans with Disability Act [1] requires educational institutions to provide accommodations to students with diagnosed physical, mental, and psychological disabilities. Accommodations for students with physical disabilities may include braille texts, accessible classrooms, or transcripts. Mental disabilities such as learning disabilities, ADHD, or autism may have accommodations such as extended time for tests and assignments, reduced distractions, and note-taking services. More excused absences, extended time, and a reduced course load may accommodate psychological disabilities such as depression, anxiety, and bipolar disorder. [2]

Accessing accommodations in higher education is not straightforward. Many students remain unaware of available resources and obtaining a formal diagnosis can be costly and time-consuming, disproportionately affecting underrepresented groups [3]. Students from less privileged backgrounds are less likely to have used accommodations in high school and may have experienced less parental advocacy [4]. This can combine with other underrepresented identities to increase inequity. Students may be unsure what accommodations they should request. Disability offices may be understaffed and some faculty may resist providing accommodations for a variety of reasons [5].

There is a difference between accommodations to level the playing field and interventions to teach skills or scaffolding to achieve maximum potential. Interventions such as executive function coaching have been shown in some studies to lead to statistically significant improvements in student outcomes [6]. Accommodations provide access to higher education but do not guarantee success [5]. When interviewed, students with disabilities have definite desired outcomes from their accommodations [7]. They would like to learn self-advocacy skills that will allow them greater autonomy. They want to be prepared for careers from hiring to day-to-day skills to succeed. Students also want to be full members of the university. This requires the university to change the physical environment, knowledge, and awareness of social issues related to disability and promote inclusive teaching practices.

Post-Secondary Students with Disabilities

According to the NSF [8], 9% of the US population has at least one disability. The definition of disability used by the NSF focuses primarily on physical disabilities without much detail about invisible disabilities. Other sources estimate that 15-20% of the US population has some form of neurodivergence, such as autism disorders, ADHD, depression, anxiety, learning disabilities, and dyslexia [9]. Mak et al. [10] determined that approximately 16% of incoming college students have ADHD. Despite this, only 8% of Ph.D. degrees in engineering were earned by disabled students in 2021 [8]. 65% of STEM workers with at least one disability have not completed a bachelor's degree.

A recent paper by Danowicz and Beddoes [11] found that mental health problems, already on the rise in college students, are a major problem for engineering students. Their study used a combination of common screening tests for mental health disorders such as anxiety, depression, and PTSD to survey first- and second-year engineering students. They found that 50% of the engineering students in their study screened positive for major mental health disorders despite only 16% having a formal diagnosis. Compared to male engineering students, women in engineering are more likely to screen positive for panic disorder, other anxiety disorders, PTSD, or major depression. Students with physical disabilities are also more likely to be screened for mental health disorders, including being 2.9 times more likely to screen positive for PTSD. Although this study did not specifically mention invisible disorders, the fact that many students are suffering from undiagnosed mental health problems may point to the need for additional support and universal design for learning to support this population.

Disability and Team Dynamics

Teamwork is a necessary skill in college and the workplace and team- and project-based learning is becoming standard in engineering education. Even non-disabled students can struggle with teamwork due to incompatible schedules or unequal work distributions. Neurodivergent students may face challenges in teamwork due to executive function difficulties (e.g., time management, task sequencing), social communication differences (e.g., misreading cues, difficulty expressing ideas), or workstyle variations (e.g., last-minute productivity, hyperfocus on specific tasks). These factors can lead to misunderstandings, uneven workload distribution, and team tensions [12]. Physical disabilities can potentially limit meeting places and other students may equate physical disabilities with mental incompetency [13]. Although the current generation of students is generally more knowledgeable about and tolerant of disabilities than some past generations [14], this is not universal.

Less visible disabilities may also cause friction in teams. Students may be reluctant to disclose conditions such as autism, depression, or ADHD [15]. Last-minute work provides little time for review and corrections, which can cause stress and anxiety on the part of the other students. Students with learning disabilities or dyslexia may make mistakes or struggle with content, which can cause an added burden on the other team members [16]. If students are behind in a different class, they may divert their resources and attention to that course, leaving their team members with extra work. Without disclosure, the only conclusion that team members can draw is that their teammate is not pulling their weight.

Another set of difficulties stems from social and sensory struggles faced by neurodivergent students, particularly those on the autism spectrum [17]. Students who miss social cues may not be aware of signs that other students are becoming frustrated with their work or their behavior. It can be difficult for neurotypical students to understand sensory overload or stimming behaviors, which autistic students use to manage their symptoms. Autistic students may have difficulty during discussions by interrupting others, going off on tangents, or appearing uninvolved. These struggles may require coaching for all students, as neurotypical students may not be aware of the implications of neurodivergence and neurodivergent students may need to learn specific skills [18]. As stated earlier, this is predicated on a student disclosing their disability, either formally to obtain accommodations or informally to their peers or instructors. Overall, a lack of understanding and awareness of the strengths and challenges of various disabilities can lead to difficulties in teamwork and unfair assessment by their peers.

All this is not to say that there are no successful ways for students with invisible disabilities to work on teams with other students. Some authors have shown that providing scaffolding for group work, including assessment for time management feedback on group progress toward meeting goals and information about different modes of thinking, can help students work with less difficulty [12]. Others have found that portfolio-based work can allow students to demonstrate their knowledge of the material as a supplement to group-based work [19]. Students with disabilities are offered many types of support, but some researchers have found that self-advocacy training is particularly effective [20]. This type of intervention helps students to speak up, rather than letting disagreements fester or allowing misunderstandings to persist. General neurodiversity awareness and promoting inclusive classroom ideas also help reduce group problems. [13]

There are gaps in the literature around teamwork and students with invisible disabilities. Technology exists that can help students with autism translate social interactions [21]. It is possible to transform workspaces to be more neuroinclusive, however, the field requires more research [22]. Neurodiverse students often find they work well with other neurodiverse students as they understand each other. Still, there must be ways to connect these students without them needing to disclose their disability to the entire class [21]. Additionally, increasing teamwork in class and in projects and labs can be overwhelming for neurodivergent students who may be better served with anonymous technology, but this also requires additional consideration [23].

Peer Assessment of Teamwork

Peer assessment of team functioning is well-known in engineering education. Planas-Llado et al. studied the interaction between peer feedback on teamwork and final grades [24]. They found that the best-functioning teams tended to rate all the team members equally, which validates the methods described in this work. They found that students who viewed their efforts as positive and effective rated their team members similarly. Other researchers found that discussing best practices for teamwork with students in detail led to better team outcomes [25]. They also found that instructors who facilitate peer feedback and coach students through frank discussions between group members can guide their students toward more effective teamwork. There is some concern among researchers that students are not able to evaluate their peers fairly [26], but other researchers found that students were able to evaluate their peers if multiple students rated each

other individually [27]. Providing teamwork guidelines, even for shorter-term collaborative assignments, can reduce bias in peer assessments. Students who were given guidelines performed better and found peer assessments more valuable than those who were not [25]. Peer assessment results could be potentially influenced by ableist biases. However, as students were rarely seen to identify their disabilities to their peers, it is more likely that biases were due to behavior or personality issues without those issues being specifically linked to disabilities.

The current study had instructor-formed groups and used simple forms that students uploaded to the course management systems after every lab for team assessment. This was done because there were no costs involved and no particular barrier to entry. The author recognizes that this method can be time-consuming and that web-based team formation and peer evaluation tools are available. The Comprehensive Assessment of Team Member Effectiveness (CATME) is a well-known online system [28-29]. Alternatives to CATME exist, some of which can only be used for peer and instructor feedback and others that include team formation abilities [30-32]. Some researchers think these tools are most useful as one part of a system of assessment rather than the only method of assessing teamwork skills [33]. Despite the potential convenience of these tools, the decision was made to use a low-tech solution for the initial attempt to add team assessment to the course. The data was still analyzed using Excel, and the open-ended questions were analyzed with NVivo – only the data collection was substantially different.

Course Description and Student Demographics

ME4505 is a required course for mechanical engineers at Northeastern University. The purpose of the course is to teach students how to select sensors, design experiments, analyze and explain results, and present sensors. The course emphasizes inclusive and active learning and open-ended questions. It is a completely in-person course with three 65-minute lectures and one 100-minute lab section per week. This course is graded based on six lab experiments, homework assignments, in-class problems, and a term project. The lab experiments and term projects are performed in instructor-formed groups of three to four students, which remain throughout the course. The lab experiments are reported in two individually written reports (Labs 1 & 4) and four group reports (Labs 2, 3, 5 & 6).

After each group lab report, students turn in individual Team Assessment assignments (Appendix A). These are seen only by the instructor and are meant to allow students to reflect on their teamwork skills and those of their teammates. Teams struggling with interpersonal or organizational problems are contacted to provide suggestions to improve team functioning. Examples of these intervention emails are provided in Appendix B. These suggestions may include links to useful websites or videos, templates for planning, or related articles from the literature. In the case of one underperforming group member, that individual may be contacted separately from the rest of the group to discuss what prevents them from contributing fully. This allows the instructor to attempt to head off group problems early in the term, rather than letting things fester until a crisis develops later in the term. Peer assessments were used as the primary research tool for several reasons. The laboratory sessions are taught primarily by doctoral student teaching assistants. The teaching assistants were there to aid students with troubleshooting and equipment difficulties, and to enforce safety. As such they could not act as observers. The instructor observed groups directly when they came to office hours, borrowed sensors, or

discussed group problems before or after the lecture. However, much work was done outside of lectures and lab, limiting direct observation. Peer feedback was, therefore, thought to be a better source of information on team interactions. The author acknowledges that student interviews would provide useful insight, however, the study initially focused on the quantitative data and key students had graduated. It was ultimately considered more important to study the newly instituted team assessments from their inception.

This study examined the team assessments for the Spring 2023, Fall 2023, and Spring 2024 terms. The Team Assessment forms were introduced beginning in Spring 2023. A total of 118 teams were examined over the three terms, as shown in Table 1. While the number of students and teams fluctuated over the three terms, the gender mix in the classes was similar. Teams are formed with student preferences in mind, but an effort is made to avoid isolating female or BIPOC students on teams whenever possible.

Table 1: Demographics of teams studied.

Term	#Teams	#Students	#Men (%)	#Women/Non-Binary (%)
Spring 2023	38	136	100 (74%)	36 (26%)
Fall 2023	34	106	81 (76%)	28 (24%)
Spring 2024	44	164	120 (73%)	44 (27%)

Each term the campus disability support office sends emails to the instructors to inform them of students who have official accommodations. As shown in Table 2, the percentage of students requiring accommodations did not vary much from term to term. Interestingly, nearly all the students with accommodations were male in Spring 2023. In the other two terms, the students with accommodations were evenly or nearly evenly split between genders.

Table 2: Percentage and gender of students with disability accommodations.

Term	# students with accommodations	% of total students	#Men	#Women/Non-Binary
Spring 2023	12	8.8%	11	1
Fall 2023	8	7.5%	4	4
Spring 2024	10	6.1%	4	6

Table 3 lists the type of accommodations provided by the disability office and the number of students who were afforded each accommodation. Additional time, reduced distraction, and private room accommodations apply to exams. Since this course does not have exams, these accommodations will not directly apply to this course. As these accommodations are typically given to students with ADHD, this can translate to students who have trouble focusing on what they are doing in a noisy and chaotic laboratory. Alternative format materials and extensions are typically not a difficulty. However, absences are disruptive to lab functioning as the lab only meets once per week. Efforts are made to keep students from missing lab by letting them work with another group later in the week or by arranging for them to join their team virtually. In any event, reports were written with the original group. Lab modifications are generally required for students with physical disabilities and may involve lower tables, clamps to hold equipment in

place, and baskets to carry items in the lab. For this study, the type of accommodation is less important than the underlying reason for the accommodations.

Table 3: Types of accommodations offered and number of students with those accommodations

Type of Accommodation	# Students
1.25x time	1
1.25x time, reduced distraction	1
1.5x time	5
1.5x time, reduced distraction	5
Alternate format materials, 1.5x time	1
Brief absences in class, 1.5x time, private room	1
Extensions	3
Extensions, absences	2
Extensions, absences, 1.25x time	1
Lab modification	1
One-on-one tutoring	1
Note-taking services, 1.5x time, computer in class	1
Note taking, 2x time, private room	1
Note-taking, preferential seating, 1.25x time, reduced distraction	1
Note-taking, 1.25x time, private room	1
Note-taking, 1.5x time, computer in class	1
Reduced course load, alternate format materials, absences, preferential seating	1
Reduced course load, extensions 1.25x time, reduced distraction	1
Reduced course load, extensions, absences, 1.25x, private room	1

Methods

As shown in Appendix A, each student is asked to assign the percentage of work they feel each team member contributed to the lab and the lab report. Assessments were initially evaluated for each lab experiment. Each member's ratings of their teammates were recorded and averaged to determine the average rating for each member. This is shown in Table 4, which provides data from two groups as an example. The difference between the maximum average rating and the minimum average rating for the group members was termed the 'Spread' in the ratings. A spread of zero means that all group members agreed that they had split the work evenly between them, as seen in Group A. Group B in Table 4 illustrates a group that had difficulties. Member 1 is consistently rated as doing more work than the other group members, and Member 3 is consistently rated lower than the others. The spread is, therefore, much larger for Group B, indicating possible team dynamics problems. While all written commentary in the assessments was examined, the commentary for groups with large spreads between group members was read more closely to determine where the problem lay.

Table 4: Example of two teams showing a low and high spread of ratings.

	Member 1 Ratings	Member 2 Ratings	Member 3 Ratings	Average Rating	Spread (Max Avg – Min Avg)
Group A					
Member 1	33	33	33	33.0	0.0
Member 2	33	33	33	33.0	
Member 3	33	33	33	33.0	
Group B					
Member 1	45	70	45	53.3	31.7
Member 2	30	15	30	25.0	
Member 3	25	15	25	21.7	

After all the team assessments were compiled, single-factor ANOVA with $\alpha = 0.05$ was used to compare labs within each term. The team spread values for each lab were also compared to the same lab across different terms. Next, all the terms were combined to compare the four different labs with each other. Pearson's product-moment correlation analysis was used to determine if any lab results correlated with any others. Additionally, the difference between lab 2 and lab 3, lab 3 and lab 5, and lab 5 and lab 6 will be examined to look for large positive or negative changes in the group spread values. Comparisons were also made between groups with and without students with accommodations. There was a concern that groups containing non-native English speakers might have teamwork difficulties that confounded the effect of students with disability accommodations. To combat this, additional analyses separated the teams into four groups: Accommodations, Non-Native Speakers, Both Accommodations and Non-Native Speakers, and Neither Accommodations nor Non-Native Speakers. Finally, the difference in spread between each pair of labs (labs 2-3, labs 3-4, and labs 5-6) was determined for all teams.

The open-ended responses were analyzed using NVivo software. An initial set of 10 lab reports per term, encompassing a range of spread in team scores, were coded initially to determine key themes. Table 5 lists the codes that were decided upon. It is important to remember that the responses to the open-ended questions tend to be no more than two to three sentences for the most part, although some were longer or shorter. This led to a relatively short list of codes. After the codes were developed, NVivo was used to search for instances of the codes in the rest of the responses. This was repeated for all three terms.

Table 5: Codes used for NVivo analysis

Name	Description
Arduino	Comments about Arduino coding, software, and hardware problems
Bad Dynamics	Comments relating to teams not getting along
Communication	Comments related to good/bad communication between team members
Content Questions	Comments related to team members not comprehending course content
Good Dynamics	Comments indicating team members working together well
Poor Quality Work	Comments indicating that other members' work was sub-par and needed to be reworked before submission.
Team Meetings	Comments related to teams being able to meet outside lab
Time Management	Describes getting tasks done on time, at the last minute, or disagreements on when things should be done, or similar comments
Unequal work	Comments relating to students not working equally on the tasks

Results

After collecting and collating the team assessments from all the teams, the spread between the highest and lowest average rating for each team, lab, and semester were compared to each other in several ways. For the first analysis, the results of which are given in Table 6, the results for all teams and terms were combined for each lab experiment. The results for each experiment were divided into four groups: teams that had at least one person who had accommodations for a disability (Accommodations); teams that had at least one person for whom English was their second language, but without any accommodations (Non-Native Speakers); teams that had neither non-native speakers nor accommodations (Other); and teams that had members with accommodations and members who were not native speakers (Accommodations + Non-Native Speakers). For each lab, one-way ANOVA was used to compare the four groups to determine if there were statistical differences between them. The P-value provided in the table was the result of the ANOVA analysis ($\alpha = 0.05$). Of the four labs, only Lab 2 had statistical differences between the groups. Further analysis using two-tailed t-tests confirmed that the Accommodations group had a statistically significantly higher average spread than the other groups. Although the Non-Native Speakers group had a slightly higher average spread than the remaining groups, the difference between the averages was not significant. None of the other labs had significant differences between any of the groups, although there were some interesting features in the data. For Lab 3 both groups that contained students with disabilities had higher averages than those without. Lab 5 results indicated the Others group and the Accommodations group had the highest averages, although again, the differences were insignificant. Finally, the Accommodations group had a noticeable but insignificant difference in average spread in Lab 6 compared to the other groups. It should be noted that the two groups that had students with physical disabilities each had maximum spreads of 5, which is much lower than most groups with invisible disabilities. This agrees with literature evidence that neurodivergent students have unique struggles in higher

education [15]. Additional analysis showed that there was no significant difference in average spread per lab when compared across terms.

The statistically significant difference ($P = 0.0006$) between the Accommodations group and the other groups for Lab 2, but not for the other labs, was an interesting finding. The first lab experiment (Lab 1) has an individually written report. The experiment requires students to share data between group members, but this data can be collected more or less independently. One of the explicit goals of Lab 2 is to practice designing experiments. This requires the teams to plan the procedure together, physically cooperate to obtain all the measurements, and write a group report. This is, therefore, the first lab that requires interdependence among the group members. At this point in the term, teams may not have fully established norms or agreed on communication methods.

Teams with students requiring accommodations had nearly double the number of comments on communication challenges and poor team dynamics compared to their peers. One student noted,

“I think we could probably have more communication between members while writing the report. We’ve been dividing and conquering sections of the lab report, but I think a lot of the stuff should be more cooperative in nature amongst sections.”

when reflecting on early struggles. Another mentioned:

“My group mates stopped working at about 8:30 pm on Friday night when the report was due. The report was not done. I believe they think they had done their fair shares, and so had I, but the report was nowhere near complete. Eventually, [teammate] came back to help (and also help with the unfinished project update due at the same time). I think our group needs serious help with the time management aspect of running experiments and writing reports.”

highlighting the need for clearer role expectations at the beginning of the term. These results suggest that early-term intervention in group communication norms may help mitigate initial disparities in teamwork performance.

Team interventions after Lab 2 prioritized the students with the largest spreads between group members. Interventions from the instructor were tailored to the specific group issues reported. For example, if a group member had not been responding to texts, that group member would be asked privately if anything was going on that prevented them from responding. At the same time, the entire team, including the group member, was told that several members had discussed communication problems and had different expectations about response times. A suggestion might be made to schedule a set time for text updates or to plan their report writing strategy before leaving the lab after finishing the experiment. In some cases, just mentioning to the group that they all seemed to indicate struggles with the same issue caused them to take notice and solve it on their own. It was rare for the emails to go completely unanswered. This may explain why subsequent labs had no statistically significant differences, even if groups with accommodations had slightly higher average spread values.

Table 6: Results for group labs and probability value from one-way ANOVA

Lab 2	Average Spread	P-value
Accommodations	10.8	0.0006
Non-Native Speakers	5.1	
Other	3.9	
Accommodations + Non-Native Speakers	3.1	
Lab 3	Average Spread	P-value
Accommodations	7.1	0.33
Non-Native Speakers	4.7	
Other	4.1	
Accommodations + Non-Native Speakers	7.0	
Lab 5	Average Spread	P-value
Accommodations	6.3	0.73
Non-Native Speakers	4.7	
Other	6.4	
Accommodations + Non-Native Speakers	4.7	
Lab 6	Average Spread	P-value
Accommodations	6.1	0.74
Non-Native Speakers	4.6	
Other	3.9	
Accommodations + Non-Native Speakers	3.8	

Pearson's product-moment correlation coefficients were determined between the spread for each of the four different lab experiments for each group. Correlation coefficients between 0.5 and 0.7 were considered moderate correlations, while correlation coefficients above 0.7 were considered strong correlations. These results are summarized in Table 7. For the Accommodations group, there were moderate correlations between the spread for Labs 2, 3, and 5 with Lab 6. This indicates that large disagreements about how much work each person was doing were somewhat likely to persist throughout the term. Lab 6 is a lab that involves a great deal of cooperation and many different sensors along with difficult calculations. Early friction between group members that is not resolved can blow up during the last lab and the term project, which is due a few weeks thereafter.

For non-native speakers, there were strong correlations between the Lab 2 spread and Labs 3 and 6, and between Labs 3 and 6. The correlation between Lab 5 and Lab 6 was moderate. The effect of non-native speakers seems to be more marked than the effect of accommodations. For the Others group, there were no strong correlations and only one moderate correlation between Labs

5 and 6. This may speak to end-of-term time crunches leading some students to fall behind on their tasks. Interestingly, the Accommodations and Non-Native Speakers groups had one strong correlation between Lab 3 and Lab 6 and another moderate correlation between Lab 5 and Lab 6. It seems that these groups may be able to use the students' combined strengths to get through Lab 2, but problems in the more difficult Labs 5 and 6 are magnified in struggling teams. This may be caused by a combination of writing difficulties for the more challenging reports and executive function skills being pushed to their limits.

Table 7: Correlations between lab experiments for different groups

Correlations between labs, Accommodations				
	<i>Lab 2 Spread</i>	<i>Lab 3 Spread</i>	<i>Lab 5 Spread</i>	<i>Lab 6 Spread</i>
Lab 2 Spread	1.00			
Lab 3 Spread	0.42	1.00		
Lab 5 Spread	0.28	0.41	1.00	
Lab 6 Spread	0.55	0.69	0.59	1.00
Correlations between labs, Non-native speakers				
	<i>Lab 2 Spread</i>	<i>Lab 3 Spread</i>	<i>Lab 5 Spread</i>	<i>Lab 6 Spread</i>
Lab 2 Spread	1.00			
Lab 3 Spread	0.72	1.00		
Lab 5 Spread	0.36	0.43	1.00	
Lab 6 Spread	0.70	0.70	0.52	1.00
Correlations between labs, Other				
	<i>Lab 2 Spread</i>	<i>Lab 3 Spread</i>	<i>Lab 5 Spread</i>	<i>Lab 6 Spread</i>
Lab 2 Spread	1.00			
Lab 3 Spread	0.41	1.00		
Lab 5 Spread	0.46	0.10	1.00	
Lab 6 Spread	0.32	0.16	0.69	1.00
Correlations between labs, Accommodations and Non-Native Speakers				
	<i>Lab 2 Spread</i>	<i>Lab 3 Spread</i>	<i>Lab 5 Spread</i>	<i>Lab 6 Spread</i>
Lab 2 Spread	1.00			
Lab 3 Spread	0.42	1.00		
Lab 5 Spread	0.06	0.42	1.00	
Lab 6 Spread	0.24	0.83	0.58	1.00

The next analysis looked at the differences (deltas) in average spreads between each pair of labs. The results are shown in Table 8. A negative value in this case is desirable as it means that the spread between group members has dropped, indicating more agreement and more even distributions of tasks. There was no significant difference between the average deltas based on one-way ANOVA.

Table 8: Differences in average spread between pairs of labs

Groups	Average	P-value
Delta 2-3	0.17	0.08
Delta 3-5	-0.80	
Delta 5-6	1.39	

Table 9 shows the results of a correlation analysis between the spreads for the different labs and the deltas between each pair of labs. There were no strong correlations found. There were moderate negative correlations between Lab 3 and Delta 2-3 and between Delta 3-5 and Delta 5-6. This indicates that large spreads in Lab 3 were associated with small changes between Lab 3 and Lab 5. This supports previous results that show that large spreads in Lab 3 are likely to persist. Small changes in Delta 3-5 are associated with large changes in Delta 5-6. This result is more difficult to interpret. It could mean that large improvements from Lab 3 to Lab 5 may be associated with the ability to retain those improvements between Lab 5 and Lab 6. However, more data would be required to prove this result.

Table 9: Correlations between average lab spreads and deltas

	<i>Lab 2 Spread</i>	<i>Lab 3 Spread</i>	<i>Lab 5 Spread</i>	<i>Lab 6 Spread</i>	<i>Delta 2-3</i>	<i>Delta 3-5</i>	<i>Delta 5-6</i>
Lab 2 Spread	1.00						
Lab 3 Spread	0.48	1.00					
Lab 5 Spread	0.31	0.23	1.00				
Lab 6 Spread	0.48	0.45	0.61	1.00			
Delta 2-3	0.46	-0.56	0.05	0.00	1.00		
Delta 3-5	0.12	0.59	-0.65	-0.16	-0.48	1.00	
Delta 5-6	-0.19	-0.24	0.45	-0.43	0.06	-0.56	1.00

Qualitative results

A textual analysis of the peer feedback was performed to determine whether there were common themes between different groups. In this analysis, the assessments for all labs for each term were combined. Individual assessments were separated into three groups: individuals with accommodations (Group members with Accommodations); the group members of those with accommodations (Group members of Accommodations); and individuals in groups without students with Accommodations (No Accommodations). These three groups were analyzed using the NVivo software. Additionally, a selection of teams with students with accommodations was analyzed by close reading to compare the comments of the various team members throughout the term.

Text analysis using NVivo

Students with accommodations often rate themselves more negatively than their team members rate them. Communication issues and unequal work distribution were reported more frequently by teams containing students with accommodations. Some groups showed positive changes over time, others struggled consistently throughout the term, and some groups did not indicate major difficulties until the most challenging lab experiments.

A key difference between students with accommodations and their team members was the list of difficulties mentioned by each group. NVivo analysis revealed key differences in self-perception versus peer perception in teamwork. Students with accommodations more frequently mentioned time management struggles, while their teammates reported communication challenges and uneven workload distribution. Students with autism or ADHD may not notice subtle cues about work distribution or unspoken 'rules' of communication. However, accommodations and coaching for these students are often focused on executive function issues instead of social difficulties. This points to a need to consider social accommodations or coaching for some neurodivergent students.

Initial coding came up with 9 themes: difficulties with coding or using Arduino sensors (Arduino), negative interactions between group members (Poor Team Dynamics); difficulties in contacting teammates or conveying information (Communication); confusion about class content (Content Questions); positive interactions between group members (Good Team Dynamics); group members producing poor quality work (Poor Quality Work); difficulties in finding times to meet or members missing meetings (Team Meetings); work being done at the last minute (Time Management); and team members who did less work than others (Unequal Work). Additionally, the sentiment analysis function in NVivo was used to determine if comments were very positive, positive, neutral, negative, or very negative.

Table 10 below shows the NVivo results for Spring 2023, which was the term during which the team assessments were introduced. In the table, some results of interest are highlighted. For example, fewer individuals with accommodations felt that there were poor team dynamics compared to their group members. None of the students with accommodations complained about poor quality work, while 30% of the students who complained about poor quality work were the teammates of these students. Students with accommodations made up 26% of the very positive

comments but the group members of these students made up 31% of the very negative comments. This provides more evidence of the disconnect between how the students with accommodations view interactions compared to how their team members view the teamwork.

Table 10: NVivo results for Spring 2023. Results are given in terms of the percentage of individuals whose assessments showed evidence of the different codes.

Code	Spring 2023 All Labs		
	Group members with Accommodations	Group members of Accommodations	No Accommodations
Arduino	11.47%	15.59%	72.95%
Poor Team Dynamics	5.98%	16.00%	78.02%
Communication	8.16%	17.71%	74.13%
Content Questions	5.65%	13.85%	80.50%
Good Team			
Dynamics	10.37%	18.54%	71.09%
Poor Quality Work	0.00%	30.34%	69.66%
Team Meetings	5.90%	19.17%	74.93%
Time Management	6.66%	18.89%	74.45%
Unequal work	5.04%	18.72%	76.24%
Positive	12.91%	18.26%	68.83%
Very Positive	26.06%	13.86%	60.08%
Moderately Positive	5.33%	20.80%	73.88%
Negative	12.71%	21.17%	66.12%
Moderately Negative	10.04%	15.78%	74.19%
Very Negative	18.02%	31.87%	50.12%

The NVivo results for Fall 2023, shown in Table 11, had some similarities. Again, the group members of students with accommodations mentioned poor team dynamics more than students with accommodations. Poor quality work was not noted, which could be a case of needing to train the coding engine more thoroughly. However, additional analysis did not turn up any particular mentions of poor quality work on anyone's part. Instead writing issues, there were more complaints about team members not understanding concepts well enough to contribute fully. Nearly twice as many group members of students with accommodations described unequal work. Although time management is typically associated with executive function difficulties, which is common in neurodivergent people, both those with accommodations and their group members were nearly equally mentioning time management. More group members of those with accommodations had positive or moderately positive sentiments than in the previous term. Communication, team dynamics, and team meeting complaints were very similar between the people with accommodations and their group members. Overall, the differences were less striking in Fall 2023 between students with accommodations and their team members, which could indicate improved skills in intervention on the part of the instructor.

Table 11: NVivo results for Fall 2023. Results are given in terms of the percentage of individuals whose assessments showed evidence of the different codes.

Code	Fall 2023 All Labs		
	Accommodations	Group members of Accommodations	No Accommodations
Arduino	18.47%	15.06%	66.48%
Poor Team Dynamics	0.00%	66.67%	33.33%
Communication	18.04%	19.32%	62.64%
Content Questions	11.67%	33.37%	54.97%
Good Team			
Dynamics	17.41%	14.34%	68.25%
Poor Quality Work	0.00%	0.00%	0.00%
Team Meetings	18.90%	20.52%	60.59%
Time Management	17.87%	20.00%	62.13%
Unequal work	16.04%	68.87%	15.09%
Positive	11.52%	22.40%	66.08%
Very positive	16.93%	15.03%	68.04%
Moderately positive	9.18%	25.59%	65.23%
Negative	14.36%	15.35%	70.29%
Moderately negative	13.41%	14.98%	71.61%
Very negative	16.92%	16.32%	66.76%

Finally, Table 12 shows the NVivo results from Spring 2024. Before Spring 2024, all sections of the course were taught by a single instructor who had been teaching the course for 13 years. Spring 2024 was different from the previous two terms in that one instructor taught two lecture sections while a new instructor taught the third lecture section. The teams could contain students from any of the three lectures, which could magnify any difference between the experienced and novice instructors. There seems to be an increase in the number of content questions mentioned in the assessments, particularly among the students with accommodations. As before, the group members of those with accommodations had more comments about poor team dynamics and communication issues. All of the detectable instances of poor quality work came from the assessments of the group members of students with accommodations. This term seemed to show a fair amount of disconnect between the students with and without accommodations. The sentiment analysis items were higher for group members of those with accommodations as well. One explanation for this could be that there seemed to be a large proportion of students who either did not turn in the assignment or who turned in assessments with one- or two-word answers. These may have skewed the answers somewhat, and more analysis is needed.

Table 12: NVivo results for Spring 2024

Code	Spring 2024 All Labs		
	Accommodations	Group members of Accommodations	No Accommodations
Arduino	16.44%	0.00%	83.56%
Poor Team Dynamics	5.34%	20.05%	74.61%
Communication	4.22%	20.34%	75.45%
Content Questions	35.37%	19.05%	45.58%
Good Team			
Dynamics	4.09%	16.21%	79.70%
Poor Quality Work	0.00%	100.00%	0.00%
Team Meetings	13.46%	30.38%	56.15%
Time Management	4.36%	18.54%	77.10%
Unequal work	5.95%	22.00%	72.06%
Positive	3.18%	19.54%	77.28%
Very positive	1.54%	22.02%	76.44%
Moderately positive	4.05%	18.22%	77.73%
Negative	5.02%	17.50%	77.48%
Moderately negative	4.87%	18.23%	76.90%
Very negative	5.47%	15.43%	79.10%

Descriptive analysis

The descriptions below present the profiles of three groups that provide narratives about different groups with neurodivergent students. All quotes are taken from student assessment forms. Any observations from the instructor occurred during informal discussions during office hours or before or after class. Additional observations were taken from email and Microsoft Teams chat interactions with students.

Group 7 – Fall 2023

This group had the largest average overall spread value of 30. The group consisted of a nonbinary student whose accommodations were extensions, twice the allowed number of absences, and 1.25x time on exams; a second nonbinary student who had an ADHD diagnosis with no formal accommodations; and a male student with no reported disabilities. The student with accommodations tended to take charge and would complete a large portion of the group lab report immediately after the lab. They were rated highly by both of their teammates, and more than 50% of the work was attributed to them. The student with ADHD but without accommodations was often late with their part of the report as they tried to juggle other classes. These two students were very self-aware and freely discussed their neurodivergence with the instructor. The student with accommodations, DJ¹, wrote in their assessment after lab 2:

¹ All names are pseudonyms.

“Our group could improve communication, before and after the labs. I could be reaching out before the labs to make sure everyone understands what our plan is and that we are on the same page. Since I tend to take charge of the labs and reports, I should step back a bit and give them the opportunity to lead if they want to.”

DJ recognized their tendency to react to anxiety by taking over and doing most of the work. Alex, who was aware of their neurodivergent tendencies but did not seek accommodations, wrote this about their own work:

“I want to make it clear that anywhere I put anything about me, I may be underestimating my ability. I feel like [DJ] did a lot for the lab, while I was just stressing over what I had to do for other classes. I wouldn’t be surprised if I’m also underrepping (sic) myself but I don’t really know.”

Alex’s comment is typical of many neurodivergent students who are nervous or self-conscious about their conduct in the lab group. The third member of the group, Robert, had this to say about what he needed to improve:

“[DJ] picked up a bit more work than [they] probably needed to. [DJ] decided to be group leader for this report and worked hard (which I am very appreciative of). But I think if I started earlier, I could have taken more of [their] workload before [they] proactively completed it. I guess our goal for the next lab should be to allocate work more equally.”

Robert did not seem to pick up on any difficulties related to the other students’ disabilities. As the term went on, Robert was the student who was slowest to respond to group texts and there was concern on the part of the others that was best summarized by Alex:

“I worry about the lack of decision making that [Robert] seems to have. While it may come from tiredness of being a student, I do worry that he’s indirectly pushing certain decisions onto [DJ] and I... Also I will bring some attention to myself in that I woke up late again and got to lab a bit late. I also worry about the entire teams (sic) lack of assertiveness, as no one really wants to be ‘the bad guy’. [DJ] and I both love labs, but my personal schedule kind of drains that excitement from me.

This group illustrates both the benefits and challenges of students with disabilities. Their commentary also shows that non-disabled/neurotypical students are overwhelmed with work from other classes and life in general. In the end, they did well on the labs and the group term project, with everyone coming together after individual and group intervention.

Group 14 – Spring 2024 with a large spread and someone with accommodation

This group also had a large overall spread of 23.1 for Lab 2. The group consisted of four students: Charity, a female who had accommodations that included a reduced course load, extensions, more allowed absences, 1.25x time on exams, and a private room for exams; Anne, a female with no accommodations; Leo, a male with no accommodations; and Sonali, a female student who was born in India and grew up in the U.S. who had no accommodations. Charity and Anne were friends outside of class who worked well together. Charity experienced a fair amount

of anxiety if work was done last minute. Leo initially did his work at the last minute but responded well to intervention and started to contribute more as the term progressed. Sonali went to India with her family for a religious event at the time that Lab 2 was being performed and written. Although she did give both the instructor and her team advanced warning, her team members did not feel that she had contributed her fair share. Charity expressed her anxiety and need for structure by saying:

"[Anne] and I are very eager planners, and we usually want to allot time for the lab to sit down as a group to be productive. Despite [Anne] and I being friends, we still maintain this mindset in other groups where we do not work together, it is just our personalities and work ethic. Our group mates do not necessarily reciprocate this level of work ethic and organization. Prior to sitting down as a group on Monday night, [Leo] and [Sonali] had completed the procedure and equipment description 30 minutes before our meeting. This could have been seen as productive, but they had considered this as "their part" of the report. I was not trying to seem ungrateful, but it was clear that they were taking the lighter route. [Anne] and I had done the tables for previous labs and because we are proactive, we always seem to be the ones always supplying the group with the information. I understand that my group is busy with other commitments, but I also am too. It just gets frustrating when [Anne] and I are expected to pick up the slack simply because it is in our nature. We try to communicate this, but I think it is not taken seriously."

Throughout the term Charity, and Anne to a lesser extent, struggled to let go of the resentment they felt after Lab 2 and had very different expectations of how much work should be devoted to the lab. Charity and Anne felt that anything less than 4 hours spent on the lab was not enough. Leo provided short, noncommittal answers in all of the team assessments that provided little insight. In contrast, Sonali seemed oblivious to her teammates' feelings when she said:

"As a team, this is an absolutely amazing team to work with and I am very grateful for these great teammates. I often feel like everyone is putting in 110% but I am unable able to do that, so I feel like I need to contribute at that same level to feel like a productive member of the team, but ultimately I know everyone is working together to get the job done."

After the Lab 2 assessments were graded, the instructor communicated individually with Sonali with suggestions about how to contribute more in subsequent labs. The entire group was sent information about time management and equal contribution (see examples in Appendix B). Leo, Charity, and Anne coalesced into a coherent and cooperative team after this, but Sonali continued to disappoint her teammates. As Anne put it:

"It has been a struggle to write the group reports due to a member only thinking about her time commitments when we are all very busy. It would be easier if everyone would pull their weight. Group reports mean you have to sacrifice time to make it work for everyone."

Sonali's response in her Lab 5 assessment showed that she was still not on the same wavelength as her team. The spread in lab scores decreased somewhat during the term, primarily because Sonali usually rated all team members as having contributed equally. Her view was expressed in this way:

“I am really trying my best to help the team and be a supportive member who is bringing equal to the team but I get the feeling I might not be doing enough. I am going to continue to just try my best and engage in teamwork as much as possible.”

Despite repeated interventions, Sonali never contributed at the same level as her teammates and never seemed to be fully aware of how her team members perceived her. The instructor attempted to support the other three group members with different strategies, but in the end, this group did not have a successful intervention. At the end of the term, Charity was extremely disappointed in the teamwork experience and felt that the professor could have done more to fix the situation. Her Lab 6 reflection ended with:

“One thing I learned about teamwork is that you cannot force someone to be as committed to a project/task as you might be.”

This group was a series of contrasts. Charity, who had suffered a severe head injury the previous summer and struggled with anxiety, was very fixed and rigid in her expectations. Lab reports were supposed to take a fixed amount of time and be finished a certain number of days in advance of the deadline. Anything that strayed from that expectation caused her anxiety to flare up and feel that others were not contributing fully. In contrast, Sonali had no known conditions or disabilities yet went through the term seemingly unaware of her teammates' irritation. Anne and Leo were initially caught in the middle but eventually sided with Charity. This team might have benefitted from face-to-face group interventions earlier in the term.

Spring 2023 - Group 15

This group had a very small overall average spread of 2.5. The group consisted of three male students. Jozef had no accommodations, Luke had 1.5x time on exams, and Sam had accommodations that included note-taking services, 2x time on exams, and a private room for exams. Sam spoke openly about his autism and ADHD to the instructor and was aware that he sometimes blurted out answers in the middle of lectures or during discussions. On the start-of-class survey, several individuals mentioned Sam as someone they would prefer not to work with. However, a few factors worked in favor of this team. It happened that Jozef and Sam were extremely interested in space-related engineering, one having done a co-op at a NASA facility and one who was working part-time in a robotics lab on campus. Luke was quiet but seemed unfazed by Sam's energy as he had a more inattentive version of attention deficit disorder. Lab 2 elicited minimal response from Luke and Jozef, both of whom said the experiment went well but they could have used additional preparation. Sam was more colorful and said:

“Group 15 could do better by being more aware of what we need to do during the lab before we arrive, so that we aren't running around like headless chickens on the day of the lab.”

Although the instructor did not perceive any major difficulties from the group, they were still sent intervention material about communication and preparing for lab (Appendix B). In subsequent labs, Jozef's team assessments were essentially identical to Lab 1 and consisted of 2- to 4-word responses. Luke gave slightly longer answers, generally referring to the need for more communication. However, Luke did notice an improvement in the group over time:

“I think we used to struggle with communication prior to the lab, but for lab 6, we were prepared relatively well.”

Sam showed insight and awareness of his and his teammates’ struggles and provided more details than the others. For example, after Lab 5 Sam had this to say:

“I was distracted but Luke kept me on task and it was helpful during the lab time... We have gotten accustomed to each other.”

Sam also observed that Jozef was stressed due to the pressures of his research job but was understanding and provided additional help. After Lab 6, Sam had this to say:

“I think my team is doing much better with communication. We all get along quite well when we MAKE the time to meet in person. We were very happy with the work we submitted and feel that it is a reflection upon our understanding.”

This was a group that could have had difficulties. Sam had a reputation for being loud and hyper, and several students were visibly annoyed when he spoke out in the middle of a lecture. However, the combination of common interests and common knowledge of disabilities led to a successful group that required minimal intervention. This speaks to the possibility that multiple students with disabilities on a team may be a benefit in some cases.

Discussion and limitations

The number of students with formally diagnosed ADHD, autism, and other invisible disabilities has increased over the last two decades. Current educational practice is to integrate students into typical classroom settings. One could assume that college students have interacted with one or more neurodivergent individuals before arriving at the university. However, interacting with a neurodivergent person does not necessarily mean understanding that person. Awareness that neurodiverse peers exist and an overall higher level of general acceptance doesn’t mean that students are equipped to understand the way neurodivergent people interact with and perceive the world. Students need information on these interactions the same way they need information on how to interview with a company correctly. This may need to be addressed at a college or university level for maximum impact.

Instructor-led early intervention—such as addressing communication issues and clarifying workload expectations—helped teams improve collaboration. This suggests that proactive strategies should be integrated into accommodation policies and faculty training programs. Instructor intervention for the groups with the highest spread after Lab 2 reduced the discrepancy between peer assessments to the point where there was no significant difference between the different group categories. As teamwork seems to have improved after some explicit discussion of behavior, institutions could potentially integrate teamwork support into disability accommodation. Faculty workshops to teach methods for supporting inclusive teamwork could also increase support for teams including neurodivergent individuals.

One key recommendation is to integrate teamwork accommodations into official disability services policies. Currently, most accommodations focus on exams and lecture-based coursework, but they rarely account for the collaborative nature of engineering education.

Universities could develop structured teamwork plans for students with accommodations, including predefined team contracts, communication templates, or periodic faculty check-ins to ensure equitable workload distribution.

Another recommendation is to incorporate faculty training on inclusive teamwork into engineering education development programs. Workshops could focus on common challenges faced by neurodivergent students in team settings and provide faculty with concrete strategies to support diverse teams. Such training could be integrated into departmental faculty meetings for maximum impact.

Physically disabled students did not seem to have any notable negative interactions. In Fall 2023, there were two students with physical difficulties whose teams had low spreads. Anecdotally, students that had temporarily disabled students – including one who had broken both arms in a snowboarding accident – also seemed to have no effect on their teams, as the other students were very supportive. Students with ADHD and executive function difficulties tended to cause time management and unequal work complaints in their teammates. This course is designed to have rather open-ended lab experiments with multiple possible answers. More scaffolding and reminders may be helpful for students with these challenges. In many cases, neurodivergent students underrated themselves – sometimes severely. When students were told that their team members had rated them highly, they were often surprised. These confidence boosters may also have helped level out differences between group members as the course went on.

Students with autism were often on other students' lists of people they did not want to work with. This points to the need for efforts to increase awareness of neurodivergence and promote a strengths-based approach. A brief discussion of neurodiversity, characteristics of successful teams, and solutions to common scenarios would be helpful to add at the beginning of project-based courses. Additionally, group formation could be improved by attempting to cluster students with invisible disabilities together. The discussion of Group 15 above was one example of neurodivergent students working well together, possibly because of shared experience. Team formation is challenging in this course since each lab section contains students from multiple lecture sections. Students have mentioned preferring all members of a team to be in the same lecture section to make communication easier. Team formation first considers team members who wish to work together, then common lecture sessions, and finally avoiding isolating underrepresented students. Anonymous team formation could lead to less student satisfaction in this case.

The finding that autistic students were frequently listed as 'do not want to work with' highlights a critical issue of implicit bias in team formation. Research suggests that such biases often stem from misunderstandings about neurodivergent communication styles rather than actual performance concerns. One student noted:

“[Teammate] makes me very uncomfortable; it constantly feels like he talks down to me, like he knows everything and I/we know nothing.”

suggesting that some social interactions were perceived differently by peers, even when technical contributions were strong.

Providing a brief neurodiversity training session at the start of project-based courses could help students recognize and appreciate different work styles. Simple interventions—such as explicitly discussing common teamwork challenges and providing structured role assignment tools—can significantly reduce misperceptions and improve team dynamics.

Limitations of this study include relying on the assessments and instructor communications with students. The study would be strengthened by follow-up interviews with students in the various subgroups to clarify their assessments. Direct interviews would clarify the motivations behind reported team interactions and add detail to the responses. This could additionally provide evidence as to the effectiveness of current interventions and suggest additional support ideas. Another limitation is students who wrote very short and noncommittal answers to the assessment questions. These did not provide much usable data. There is also the potential problem of groups giving each other equal credit when it wasn't deserved. However, the number of groups with spreads of zero throughout the whole course accounted for less than 10 groups per term. This seems to leave a reasonable set of assessments that contained information indicating that the student had given some thought to the assignments.

Future studies should explore how neurodivergent students perceive peer assessments compared to their teammates' evaluations. One limitation of the current study is that it relies primarily on peer assessment data and instructor observations without direct student interviews. A qualitative study with structured interviews could investigate whether students with accommodations feel that peer assessments accurately represent their contributions and whether they experience bias in how they are rated. Beyond traditional peer assessment methods, technology-based solutions may offer additional support for neurodivergent students navigating teamwork challenges. Online collaboration tools such as Slack, Discord, and Notion could help structure communication, allowing students to engage asynchronously when needed. Studies suggest that neurodivergent students often benefit from written communication over verbal exchanges, making text-based platforms an effective way to streamline group interactions [17].

Additionally, adaptive peer assessment tools could be developed to identify misalignments between self-perception and peer perception. For instance, if a student consistently underestimates their contributions compared to peer feedback, the system could prompt self-reflection or faculty intervention. More research is needed to explore whether such tools could reduce bias and improve team outcomes in project-based engineering courses.

Additional research is needed to examine whether certain intervention strategies are more effective than others. For example, do neurodivergent students respond better to faculty-led interventions, peer mentorship programs, or structured team-building activities? Understanding these nuances could inform best practices for supporting diverse teams in engineering education.

Recommendations

The main recommendations developed from this work are:

1. Peer assessment of teamwork, whether using a full-featured online tool such as CATME or a relatively low-level assessment as shown here, has value as it causes students to examine their behavior and reflect on team functions.
2. Groups that contain neurodivergent students are more likely to have early conflicts and misunderstandings that may require targeted intervention geared more toward social interactions and contracts.
3. More difficult assignments, such as Labs 5 and 6 in this study, may require additional intervention, even if the teams performed well early on.
4. Take time to email or message every team early in the term after the first or second assessment. This can be done very quickly by grouping the teams in terms of common issues – all the groups with communications issues, for example – and having prewritten information to send them with suggestions.

Instructors who take a bit of time early in the semester to check in on teams in a more detailed and structured way will most likely avoid teams that self-destruct later in the course. Students should be guided to reflect on their team dynamics, distribution of workload, and their own contributions to the team. Faculty training in supporting students with disabilities should also be provided with input from disability services.

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Appendix A: Team Assessment Forms

ME4505 Teamwork Assessment (Labs 2, 3, and 5)

The purpose of this assignment is to let me know how the teams are functioning and where people could use some extra coaching on teamwork. This feedback will only be seen by Prof. Redacted, so please be honest and constructive. Please turn this in as an INDIVIDUAL assignment after each GROUP lab report.

Your name: _____

Group number: _____

Lab number (Lab2, Lab 5, etc.): _____

Team member name (include your own name as well)	Tasks this person performed during lab	Tasks this person performed during report writing & data analysis	% of work done by this person (should equal 100% in the end)	Additional Comments

How well do you think your team is functioning?

What could you improve on?

Is there anything your team struggles with?

ME4505 Teamwork Assessment (Lab 6)

The purpose of this assignment is to let me know how the teams are functioning and where people could use some extra coaching on teamwork. This feedback will only be seen by Prof. Redacted, so please be honest and constructive. Please turn this in as an INDIVIDUAL assignment after each GROUP lab report.

Your name: _____

Group number: _____

Lab number (Lab2, Lab 5, etc.): _____

Team member name (include your own name as well)	Tasks this person performed during lab	Tasks this person performed during report writing & data analysis	% of work done by this person (should equal 100% in the end)	Additional Comments

How would you describe your overall team experience this year? How did it compare to other team experiences you've had?

What is one thing the professor can do to improve teamwork in this class?

What is one thing you have learned about teamwork or one thing you can do yourself to improve teamwork?

Appendix B: Sample intervention emails

Intervention: Group member doing unequal amount of work

In looking over your feedback, it seems that communication and being proactive about working on the lab reports is something you're struggling with. I realize that for one lab [Student] had an unexpected issue and wasn't able to communicate with the rest of the group. This seems like it may have left some lingering resentment. I encourage you all to make a fresh start for the next lab. I would suggest the three of you get together to grab a quick cup of coffee before the next lab and plan the attack for the next lab. You have a whole week before the next lab and taking a few minutes to plan ahead for the rest of the term will help reduce everyone's stress level.

Intervention: Group needs to improve communication

Your group mentioned the need for better communication and to divide work more evenly. I have a couple of suggestions that may help you with these things:

1. Set times to communicate. For example, make an appointment or reminder to check your text/email/chat/Whatsapp/carrier pigeon at a certain time each day. This way you know everyone is going to check communications at a given time. You also will give yourself a nudge to respond to people's questions, concerns, etc. It also prevents people from either ghosting or feeling ghosted by others.
2. Have a frank discussion about your individual strengths and weaknesses. Do you tend to take on too much by default? Say so. Are you better at tables and figures than descriptive sentences? Can you do Arduino in your sleep but describing figures is challenging because they're obvious, aren't they? Try to figure out what each person is good at and let them contribute more in those areas.
3. Be honest with each other about what you think about deadlines. Some folks feel that it needs to be done within 2 days of lab to be 'on time'. Some folks need a day or two to mentally process something. Some people need the adrenaline rush of the looming deadline to get focused. That doesn't mean that you shouldn't start until 10 minutes to midnight, but knowing how stressful deadlines are to different people can help with understanding.
4. Take a few minutes at the end of class to both assign and sequence tasks. What needs to be done first? What needs to wait for other things to finish? What can be done in parallel? If you're the person who needs to get on it right away, that could help make the decision on what tasks you take on for the report.
5. Be willing to ask for and offer help. If you're struggling with what to write, how to calculate, or have an emergency come up, let your team or me know early. If someone seems to be struggling, reach out. Have each other's backs.

Hopefully some of these ideas will help. The more honest you are with each other about how you personally deal with stress and deadlines, the more you'll be able to work together to get things done. For more information, see [Group Dynamics for Teams](#) by Daniel J. Levi and David A. Askay.

Intervention: Team needs to divide work more evenly

Your group mentioned the need to divide work more evenly. I have a couple of suggestions that may help you with these this:

1. Take a few minutes at the end of class to both assign and sequence tasks. What needs to be done first? What needs to wait for other things to finish? What can be done in parallel? If you're the person who needs to get on it right away, that could help make the decision on what tasks you take on for the report.
2. Use the data from Lab 2. How long did it take each person to do their part? Talk about why it took the time it did and be honest. Were you unable to start because you were waiting for the results? Did it take you 4 hours because the data was very difficult to process? Did it take 30 minutes because it was obvious, or because you rushed last minute.
3. Consider the upcoming week. If one person has three exams in the week to come and the other team members do not, give that person tasks that can be done independently of the other parts, such as the introduction or procedure. If everyone feels slammed with work, lay out a master schedule and see who has time on what day. The person who has free time first should do the results, which allows everyone else to build off of them.

Hopefully some of these ideas will help. The more honest you are with each other about how you personally deal with stress and deadlines, the more you'll be able to work together to get things done. For additional information, I have found that The Team Handbook by PR Scholtes, BL Joiner, and BJ Streibel is very helpful, and is available through the library.

Intervention: Group is unprepared for lab

Your groups seem to be doing fairly well, but all of your teams mentioned the need to prepare before coming to lab. Some folks mentioned needing to look at the Arduino circuit and code prior to lab. If this has been a struggle for your group, designate two folks to work on the circuit who are able to either text or set up a Zoom/Teams meeting some time prior to lab. Even if you just spent 15-20 minutes talking through it together, you'll have a better idea of what to expect.

Also, it may help for each of you to write down a short 'to do' list for each lab session. Briefly jotting down the main things you need to do will force you to at least scan the lab handout. Spending the first few minutes of lab comparing lists will make sure everyone is on the same page. The more time you spend processing the lab handout before lab, the more efficient you will be in lab.

Finally, be on time for lab. Several groups report folks drifting in late. This not only cuts into the time you have to do the work, but it is also disrespectful of your on-time colleagues. You know what time lab is - adjust things to make sure you get there on time.

Keep up the good work, but spend a bit more time before hand to get ready. It will reduce your stress levels and you'll get more out of lab with less frustration.

Intervention: Group struggles with time management

Your groups all seem to be doing fairly well, but all of you mentioned the need for improved time management. Some things that I have seen in the past that have helped groups with this problem:

1. Put together a master calendar with everyone's schedules. If you can't find one time that works for everyone, you might be able to find time for 2 group members to meet at one time and a different subset to meet at another time.
2. Set a reminder time to communicate. Everyone can agree to check their text/email/Whatsapp/carrier pigeon at, say, noon or 3 pm. That way, even if you don't have time or don't remember to check earlier, the reminder will make sure you check the team communications at least once a day.
3. Each person should schedule a time for themselves before lab to read over the lab handout and come up with a list of questions/confusions/clarifications. These should be shared, ideally in person or via Teams/Zoom, so that people can help each other understand. If a meeting isn't possible, agree to try to address each other's questions via email and loop me in if you can't figure something out.
4. Jot notes for yourselves on what to do in lab - like a short to-do list. This can accomplish two things. First, it forces you to understand the main things that need to be done and put it in your own words. It also helps you focus during lab because if you get distracted or things take longer than you thought originally you can come back to your short list and get back on track.
5. Have a frank discussion with your group members about your tolerance for deadline stress. If you're a person who needs to have things done 2 days ahead of time to feel at ease, let your group know. Sometimes we assume everyone feels the same way - of course everyone wants to get stuff done early, right? But some people need the adrenaline of the looming deadline to help them focus. This doesn't mean you should get things done 5 minutes before the deadline so no one has time to review or revise. But it helps to actually know how people feel about deadlines so that no one is assuming anything. These are just some of many ways to manage your collective time, but these can get you started. Talking to each other is the best way to start.

Intervention: Good team dynamics but poor writing skills.

Your group seems to be doing well overall, but all of you mentioned that one or more members struggled with grammar/writing. If you don't use it already, I highly recommend using Grammarly. The basic program is free, and it points out grammar, spelling, punctuation, and wording choices. I use it constantly to improve my writing. Alternatively, the Writing Center [<link>](#) has editing services and can meet personally with you individually or as a team.