Session 3561

Integration of Communication Skills into the Introductory Material and Energy Balances Course in Chemical Engineering

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Abstract

For many years, companies have been suggesting that we must give our students more practice in oral presentations prior to graduation. More recently, ABET has added requirements for including more communication skills into the curricula in addition to all of the other topics we must cover. In response to these recent changes, we present a novel method of integrating communication skills into the introductory Material and Energy Balances Course in chemical engineering.

While it may not seem obvious, students are capable of running the discussion sessions instead of the professor or teaching assistant. We have successfully converted our traditional discussion sessions into student-run sessions with no loss of continuity in the material and no loss of rigor in the material covered. This success was carried out in a class with 56 students that met three times a week in fifty-minute lectures, and once a week for a fifty-minute discussion session.

In this work, we discuss a methodology for selecting student presentation groups to greatly reduce many problems of implementing group activities. We also discuss activities that made the transition go smoothly for these students into group work. The timeline for the discussion sessions is then described, along with the evaluation tools used to measure student performance. Student comments about the group presentations are also discussed so that a feedback mechanism for improvement in the implementation of this plan can be created. Samples of the student presentation materials are also briefly discussed.

I. Introduction

Perceptions of engineers in the popular media abound, but the most common portrayal of an engineer shows an introverted worker that exhibits little regard for personal interactions. The popular Dilbert comic strip is a prime example of this stereotype. However, engineers must have good written and oral communications skills in order to advance up the career ladder. Companies are constantly demanding more well rounded engineers. It is exciting to realize that our nontraditional approach to running discussion sessions creates skills that students can use beyond the engineering curriculum at the university.

Recent surveys show that employers consistently rate communication skills highest among the skills they wish future employees to have mastered[1], while teamwork skills come in a close second. These two skills are intricately linked; it is difficult to imagine a student who is great at teamwork, but who does not have good communication skills. The demand from employers to educate engineers more rigorously in communication and teamwork skills has led to the reevaluation of ABET accreditation criteria and the introduction of new guidelines[2].

Although some progressive schools include communication skills into many of their courses, most curricula wait until the senior year to introduce students to the topics of teamwork and communication[3]. Students normally do presentations in their senior capstone design course and in their unit operations laboratory course, but are not given the opportunity to develop skills prior to this. As the new ABET criteria are met, however, it has become important to include more team-based and communication activities at all levels of the curricula.

In this work, we show how one may integrate teamwork and communication skills into a single project in an introductory engineering course. This pilot project was executed in the introductory sophomore-level Material and Energy Balances Course with the participation of 56 students. Particular time will be spent in this paper covering the student motivation and introduction of the project to the students. These details are included because they greatly lessened student resistance to the presentation projects. Also, sample student products and comments will be shown to demonstrate the strengths and weaknesses of the approaches that were taken. The hope is that other instructors will take the best parts of this pilot project and implement them in their own courses.

II. In The Beginning

There is often student reluctance to participate in activities that are unfamiliar. While the reasons for this reluctance are many, students gain perspective and a desire to participate when the full reasons for doing the project are clearly outlined to them, which is why it is important to properly begin a teamwork or communication project.

As educators, we already know the importance of communication and teamwork skills[4-7]. However, we need to effectively communicate this knowledge to our students in order to get them interested in these types of projects. This is why it is essential to bring in the most recent employer surveys and governmental agency information that shows how communication and teamwork skills will play a role in the students' future careers. Another way to motivate the students is to have advanced students talk about their undergraduate research or intern experiences and the impact that communication skills had on their success.

Once the motivation of communication-centered projects is established, it is necessary to give the students a sense of who their peers are so that they will begin to feel more comfortable with one another. Over the past decade, student populations have become much more diverse in background and abilities[8]. Not too long ago it was unusual for nontraditional students to pursue engineering degrees. At most institutions, though, it has become commonplace for nontraditional students to make up almost ten percent of an introductory engineering course[9]. Many of these students have other demands placed on them besides schoolwork, which is why it is important to make sure all students have an appreciation for their class' diversity. Students that are procrastinators must be aware that not all students can meet late the night before their project is due. Other students need to become aware of the additional time constraints that their classmates may be under and what realistic group goals are for the project.

To address this issue, the questions listed in Figure 1 were asked of the sophomore students and they were asked to raise their hands to signify when they felt they belonged to each group. Due to legal and privacy concerns, students were also told that they did not have to answer any question they did not feel comfortable answering for any reason. However, approximately 95% of the students participated in the survey. The students commented after this exercise that it was a valuable activity that helped them throughout the semester. Some students were able to quickly identify other students of similar backgrounds so they could begin an external study group. Other students found support from students who had experience in areas of interest to themselves. They also commented that it was a great way for them to get a sense of the class' demographic distribution and get to know each other much more quickly than through traditional means.

How many students:

are true sophomores?
are chemical engineers?
are not sure what their major is yet?
are transfer students from another institution?
are from outside the state?
are from outside the country?
are involved in collegiate sports?
are married?
have children?
are involved with ROTC programs on campus?
have been in the military?
have worked in an internship or co-op?
are currently working full-time?
are currently working, but not full-time?
speak more than one language fluently?
are doing research on campus with a faculty member?
commute more than 30 miles to campus?
have commitments that would prevent them from meeting on weekends?

Figure 1 - Questions asked of students to explore the demographic distribution of the class. An activity designed to show diversity and time constraint issues they may encounter.

As students became more aware of the backgrounds of the other students in the course, it became possible to discuss the potential conflicts that could occur within the groups. Based on the previous diversity exercise, students became aware of the different time constraint issues that they would be faced with solving in order to finish their project. This is one of the biggest problems that students often face in teamwork projects; when can they meet and for how long?

Prior to beginning the presentations, we also discussed the importance of effective oral communication to prevent conflicts[10-12]. There are often many ways of saying the same things, with some of them being more aggressive and leading directly to personal attacks. We discussed some of the common ways that students often encounter these problems and how to avoid them as well.

Many students have an aversion to teamwork projects because of their previous experiences with similar activities. Many of us, too, have had negative experiences during team projects because of the way that teams were chosen. Some team choices lead to a poor performance or experience because of the selection process[13-16]. For instance, one common way to pair students is alphabetically. However, this ignores the abilities of the students and assumes that all students can be combined randomly and still be able to succeed. Another method of ensuring disaster for some students is to pair students based on GPA criteria. There are two equally poor formulations of this. One way is to pair the best student with the worst student, and so on, until the students in the middle range are paired together. This can lead to a highly unequal division of labor for a few reasons. First, the "poorer" student may be satisfied with lower grades in general and will not be willing to put in the extra effort an A requires. The "better" student will not be willing to get a lower grade and will just end up doing the project by themself, which negates the whole teamwork concept. The other worst formulation is to pair students of like ability, with the best together and the worst together. This leads to several teams that may not attempt the project. The "worse" teams will see no reason to put all the effort into the project when the deck is stacked against them. The "better" teams may succeed, but will not experience many of the team building and project execution phases that a diverse team would offer.

Regardless of how groups are chosen, the process should not occur in a black box. Also, there should be some degree of randomness so that students refrain from forming groups based upon their familiarity with each other from previous classes together. One wants to avoid situations where everyone is working with the same people they always work with since this will not be possible once they enter the workforce. Avoiding a black box process shows students there were no hidden motives or favoritism during the group selection process. Students, though, should clearly understand how they were divided up among the groups.

For the above reasons, group selection should be an open process that occurs with a purpose. The way of introducing purpose into the selection process is to lay out the characteristics that must be in each group. For instance, the following workers were important in our groups: someone who is willing to present, someone who is able to use computer software to generate supplementary materials, someone who is good at math to check the work prior to the presentation, and a jack-of-all-trades willing to pitch in during unforeseen events. Other projects may have other divisions of labor that are important, but these skills were thought to be the most important for our purposes.

Once students were made aware of how teams were going to be chosen, they were asked to raise their hands only once during each category. Due to the length of the semester and to make sure that each group had two chances to present, the number of teams was set to twelve. First, the people unafraid to present material were asked to raise their hands and the first twelve were given a number. The next group of students, those with computer skills, were asked to raise their hands as long as they had not raised their hands already. They were each given a number from one to twelve. And so on through the other two categories. Some groups ended up with multiple "jack-of-all-trade" students because of the class' size. By creating groups in this manner, the students clearly saw how the groups were chosen and how each had the same characteristics. No single group had an unfair advantage because of an uneven distribution of abilities among the groups. Because this selection methodology was used, there were no complaints from any students about how groups were selected.

However, one caveat must be made at this point. In hindsight, it is important to make sure that no group is larger than five students so that everyone gets a fair chance to contribute to the project. Due to the size of our class and reshuffling as some students dropped the course, the groups with six students commented that they wished they had been in smaller groups so they could have contributed more fully to their project.

III. The Project Details

The discussion sessions in our introductory chemical engineering Material and Energy Balances Course were used to introduce communication and teamwork skills to the students early in their academic careers. The handout used to introduce the purpose and methodology of the project is shown in Figure 2.

Discussion Session Projects

The discussion sessions will be used to solve further problems from the book. To make these sessions more active and more useful to students, student groups will be chosen to present their solution on the board. The intent is to have students learn how other students are learning the material and how they are attacking the problem solution. Each student learns differently and seeing a wide variety of solution methods will make you more aware of your own strengths. Each group will present a problem solution to the class twice during the semester, with two groups presenting each week.

Group duties may be divided among the students as they see fit, as long as each person contributes something to the finished project. Possible tasks that can be divided up are: group presenter, development of a hand out, fielding questions, creation of supplementary material, general preparation, etc. Students are encouraged to be creative while keeping their problem solution to approximately 20 minutes in length. Note: The purpose of the presentations is not to necessarily go right to the correct answer. Students should also be willing to discuss alternate approaches to solving the problem and why those solutions are better or worse than the one chosen for the presentation.

The objectives of the presentations are to:

1) learn how to use the strengths within your group to produce a finished product
2) become more comfortable and capable of giving good presentations
3) learn how to solve problems better
4) learn how other students solve problems
5) learn how to ask and respond to verbal questions

This is not meant to be a high stress event. This process is meant to be an introduction to how to present information to a target audience.

Figure 2 - Handout used to introduce the presentation projects to the students

It is not very useful to ask students to develop and use skills without demonstrating to them how to succeed or fail[17-18]. To address this issue, the last discussion session before the students began their presentations was used to give a "bad" presentation and a "good" one on the same material. The instructor performed both of these presentations, asking the students to critically analyze all aspects of their experiences. Students then identified the characteristics that made one presentation good and the other one bad.

For the poorly presented problem solution, students identified the traits shown in Figure 3 during a brainstorming session. Truly, the presentation was the worst that it could be, incorporating as many poor techniques as possible. Following the poor presentation, the same problem was presented as best as the author could present it. Student comments were again solicited before an open-ended discussion was held. Not surprisingly, the responses from the students this time were the opposite of their comments from the poor presentation. By doing this activity, the students were made aware of some of the issues that they would have to deal with and some of the problem situations they would have to avoid in order to do a good presentation.

The presentation was incomprehensible.
There was no eye contact with the class.
It wasn't clear what problem was being solved.
The board use couldn't be followed.
The handwriting was illegible.
The presenter talked too quietly and with incomplete sentences.
There were several mistakes in the information presented.
No units were shown on numbers.
Questions were aggressively answered.
Questions were left unanswered.
There was no regard for student understanding.
The presentation went too fast.

Figure 3 - Student comments after a very poor presentation

Students were also given the evaluation form that would be used during their discussion presentations so they could anticipate which criteria would be important for them to address. The form is shown in Figure 4 on the next page. The open-ended evaluation form[19] was set up to give students specific feedback from their peers after their presentation. One can see that it was necessary to provide an overall rating of the total presentation, along with evaluations of the use of the board or overhead, the verbal explanation of the group, the use of handouts, responses to questions, and appropriate use of time. The rating categories were chosen to provide as much positive reinforcement as possible. Students were asked to give specific details when a presentation was outstanding and to give specific suggestions on how to improve certain aspects when they were deficient. Surprisingly, students also often gave written comments even when they rated a category as good or needing some refinement even though this was not required.

After seeing the evaluation forms, students began to envision several ways that the presentation could be broken up into different sections so that everyone could participate. However, they were not provided with any specific guidance on how this activity should be done unless they asked for it as a group. We will shortly see how some of the groups broke up the work or introduced new categories of duties to ensure active involvement of all students.

One note needs to be made here. Implementation of this project did require a higher initial time investment than doing the discussion sessions in a traditional format. The problems to be covered had to be selected about two weeks before a group was to present, which required more foresight about where the class would be in the material at that point. However, there was less preparation time for the faculty member and teaching assistant once the problems were chosen

III. The Project During Execution

Students in the class came up with many ways of subdividing the work they had to do in order to complete their presentation. Just some of the subdivisions will be listed here. The most common way of dividing up the labor, especially during their first presentation, was to have one student make up a handout, two students solve the problem and compare answers, and one student make photocopies for the presentation along with any other errands that needed to be carried out. One of the two problem solvers would then present the problem to the class and field questions.

During the second set of presentations, more students became actively involved during the presentation instead of only performing external duties. Some groups had one person read the problem statement clearly before asking the class if they had any questions about it. Then several students took turns solving individual parts of the problem and fielding questions on their part of the solution. This change between the first presentation and the second

Evaluation Form for Presentations in ChEE 201 - Fall 2000

Peer evaluations are useful in many ways. One of the major benefits is to the group presenting the material. They get rapid feedback on how well they were able to convey their information in a professional manner while meeting constraints such as time and size of the audience. Another big advantage of using peer evaluations is the active participation of the audience. As the audience observes the presentation, they are critically evaluating how the group is presenting the material. The idea is that the evaluators will incorporate some of the ideas that worked in earlier presentations while avoiding the mistakes that previous presenters had made.

Note: No one is a great presenter without practice! This semester's presentations are to teach you some of the skills you will need later on and to make you more comfortable working in groups.

Please fill out the form below for the presentation you just saw.

1) Overall, the presentation we saw was
a) outstanding b) good c) could use some refinement d)needs help in specific areas
If (a) was chosen, explain why. If (d) was chosen, give a specific change that would help the presentation.

2) The use of the board/overhead projector was
a) outstanding b) good c) could use some refinement d)needs help in specific areas
If (a) was chosen, explain why. If (d) was chosen, give a specific change that would help the presentation.

3) The verbal explanation by the group was
a) outstanding b) good c) could use some refinement d)needs help in specific areas
If (a) was chosen, explain why. If (d) was chosen, give a specific change that would help the presentation.

4) The use of handouts/supplementary materials was
a) outstanding b) good c) could use some refinement d)needs help in specific areas
If (a) was chosen, explain why. If (d) was chosen, give a specific change that would help the presentation.

5) The responses to questions from the audience were
a) outstanding b) good c) could use some refinement d)needs help in specific areas
If (a) was chosen, explain why. If (d) was chosen, give a specific change that would help the presentation.

6) The use of the appropriate length of time was
a) outstanding b) good c) could use some refinement d)needs help in specific areas
If (a) was chosen, explain why. If (d) was chosen, give a specific change that would help the presentation.

7) List other details that really caught your eye and why (either positive or negative).

Figure 4 - The group evaluation tool used by peers to rate presentation strengths and weaknesses

presentation was exciting. It had been anticipated that because each group had a strong extrovert that only one person would present the material. However, students felt so comfortable with the feedback they received from their peers during the first round that the normally introverted students were willing to participate.

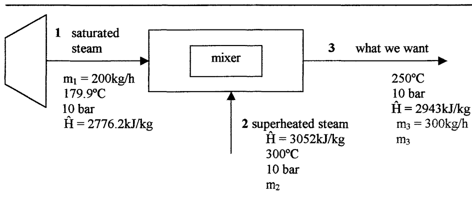
Some groups divided the work in other unique ways. Two groups tried to get participation from the class by handing out candy to students who asked questions during their presentation and would have someone designated to hand out the candy. Other groups tried to foster interaction with the class by handing out candy to those students who answered questions that the presenters asked. Some groups had students who distributed the handouts to the class, sketched the problem on the board, or did other classroom activities to help the presentation run smoothly.

Keep in mind that the students were not given guidelines on how they should do any part of the presentation or handout development. They were encouraged to try new techniques or approaches, but to be thorough and be able to answer questions from the class. Figure 5 shows an example of one handout that was generated by the students. While some of the handouts had only the problem statement, which is minimally acceptable, other handouts had background information that would be useful in solving the problems like this example. Figure 5 shows how the students clearly laid out the course objectives from the syllabus that were addressed in this problem before concisely discussing all the steps necessary to solve it. This group

GROUP #3
PROBLEM 7.35

A turbine discharges 200kg/h of saturated steam at 10.0 bar absolute. It is desired to generate steam of 250°C and 10.0 bar by mixing the turbine discharge with a second stream of superheated steam of 300°C and 10.0 bar.

a) If 300kg/h of the product steam is to be generated, how much heat must be added to the mixer?
b) If instead the mixing is carried out adiabatically, at what rate is the product steam generated?



a) $m_1 + m_2 = m_3$
$200kg/h + m_2 = 300kg/h$
$m_2 = 100kg/h$
$Q = \triangle H$
$\triangle H = \Sigma_{out} m\hat{H} - \Sigma_{in} m\hat{H}$
$= (300kg/h)(2943kJ/kg) - ((200kg/h * 2776.2kJ/kg)+(100kg/h*3052kJ/kg))$
$= 22460kJ/h$

$Q = 22460$ kJ/h

b) $m_1 + m_2 = m_3$
$200kg/h + m_2 = m_3$
$\triangle H = \Sigma_{out} m\hat{H} - \Sigma_{in} m\hat{H}$
$= m_3\, kg/h(2943kJ/kg) - 200kg/h(2776.2kJ/kg) - m_2\, kg/h(3052kJ/kg)$
$= (200kg/h + m_2)(2943) - 200(2776.2) - 3052m_2$
$= 5886600 + 2943m_2 - 555240 - 3052m_2$
$= 33360kJ/h - 109km_2\, kg/h$
$m_2 = 33360kJ/h / 109kJ/kg$
$m_2 = 306.06kg/h$
$200kg/h + m_2 = m_3$
$200 + 306.06kg/h = 506.06kg/h$

$m_3 = 506.06$ kg/h

REVIEW

Objectives from syllabus:
#1 – be able to comfortably use unit conversions while solving problems
#2 – be able to confidently transfer a verbal problem statement into its mathematical representation
#3 – be able to write and solve mass balances for a process
#7 – be able to identify and use formulas for the different energy terms
#8 – be able to use heat capacities correctly in energy balances

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Important Equations:

$$\triangle H + \triangle E_k + \triangle E_p = Q - W_s$$

$$\triangle H = \Sigma_{out} m\hat{H} - \Sigma_{in} m\hat{H}$$

Steps to solving energy balances: (pg 330, in general)
#1 – Determine, if possible, the flow rates of all stream components using material balances.
#2 – Next, determine the specific enthalpies of each stream component. Use tables B5 and B6 in the back of the book.
#3 – Write the appropriate form of the energy balance and solve it for the desired quantity.

Steps to solving part a:
#1 – Draw and label a flow chart
#2 – Look up **Ĥ** in the back of the book. Use different charts for steam and superheated steam. The values are based on the given temperatures and pressures.
#3 – Write the general equation to solve the problem: **$Q = \triangle H$** and **mass balances**
**in this problem there is no kinetic, potential energy, or shaft work
#4 – Plug in knowns and solve.

Steps to solving part b:
#1 – This part involves two types of balances: **mass** and **energy**
#2 – Write out those balances based on your known mass flow rate and enthalpies.

$$m_1 + m_2 = m_3$$

$$\triangle H = \Sigma_{out} m\hat{H} - \Sigma_{in} m\hat{H}$$

** in this problem there is no heat, shaft work, or kinetic and potential energy
#3 – Plug in knowns, use substitution, and solve.

For more practice on mass and energy balance problems, there is an excellent example on page 332-333. It is exactly like part b of this problem

Figure 5 - Sample handout created by students for their presentation.

also developed a computer presentation to go along with their problem solution that incorporated photographs of pieces of equipment and demonstrations of where that type of problem may be encountered. Figure 6 shows another handout generated by a different group. Here, the group knew they would not have time to solve the entire problem in front of the class so they added more detail to the handout about the solution steps to help the class figure out the problem later.

GROUP ELEVEN
PROBLEM 9.16

Sulfur dioxide is oxidized to sulfur trioxide in a small pilot-plant reactor. SO_2 and 100% excess air are fed to the reactor at 450°C. The reaction proceeds to a 65% SO_2 conversion, and the products emerge from the reactor at 550°C. The production rate of SO_3 is 1.00×10^2 kg/min (note that this is different from the problem in the older book). The reactor is surrounded by a water jacket into which water at 25°C is fed.

a) Calculate the feed rates (standard cubic meters per second) of the SO_2 and air feed streams and the extent of reaction ξ (kmol/s).

We'll be merciful and skip the mathematical details for this part, but here's a brief outline on how to solve this:

- Balance each species around the reactor
- Convert the mass flow rate of SO_3 to a molar flow rate
- Fill in a table
- Recall how to use the theoretical air equation
- Recall the pressure and temperature used to calculate a volumetric flow rate expressed in standard cubic meters per second

b) Calculate the standard heat of the SO_2 oxidation reaction:

$$\Delta\hat{H}r^{o} = \sum_{\text{products}}|v_i|\Delta\hat{H}_{fi}^{o} - \sum_{\text{reactants}}|v_i|\Delta\hat{H}_{fi}^{o}$$

Calculate the heat (kW) that must be transferred from the reactor to the cooling water:

- Write an energy balance equation
- Write the reaction pathway for SO_2, O_2, N_2, and SO_3

ΔH_1 : reactants are cooled from 450°C to 25°C
ΔHr :the heat of reaction at 25°C (multiply moles of SO_2 reacted to the standard heat of reaction)
ΔH_2 : products are heated from 25°C to 550°C

$\Delta H_{total} = \Delta H_1 + \Delta Hr + \Delta H_2$
This is equivalent to Q, the heat that must be transferred from the reactor to the water.

c) Calculate the minimum flow rate of the cooling water if its temperature rise is to be kept below 15°C.

When you include ΔH_3 contributed by the water (change in enthalpy from 25° to 40°) in ΔH_{total}, $\Delta H = Q = 0$

$\Delta H_3 = F_{H20}(\hat{H}_{40^o} - \hat{H}_{25^o})$ = heat that must be transferred to the water

Figure 6 - Another sample of a student handout: effective use under severe time constraints

Students were asked to write down comments and fill out their evaluation forms at the end of each twenty-minute presentation. Following the evaluations, a moderated discussion was held to discuss the strengths and weaknesses of each group's effort. The class was asked to first describe what the group did particularly well as specific details were discussed. Finally, a few minutes were spent mentioning some of the problem areas the groups had encountered along with specific suggestions on how to improve their presentation for the next time. Evaluation forms were then collected and analyzed in order to come up with a group grade based on the peer comments. The evaluation forms were returned to the group during the next class period so they could review the peer comments and make adjustments for their second presentation.

IV. End of Project Evaluations

No group project can be successful if individual accountability for each student's work[3] is lacking. At the end of each round of group presentations, the students were required to fill out the questionnaire shown in Figure 7. These evaluations were open-ended to catch some of the student sentiments that would have been ignored in a more structured questionnaire format[19]. Interestingly, students misinterpreted question number 3 and turned it into a much more pedagogically useful tool. This particular question had been meant to ask, "What would you change in the structure of the discussion section to make it more useful for you to learn how to solve problems?" The students, however, interpreted this question to ask, "What would your group do differently for your second presentation to eliminate some of the difficulties you had this time?" Because the students interpreted this question as an introspective look at their own progress, it was much more valuable to them as a learning experience. Also, it was exciting to see that most students actually followed through with their own suggestions for the second presentation.

ChEE 201
Fall 2000

Group Evaluation Form: Group #____________________ Name: ________________________

Group project work often fails in college for two major reasons: 1) the professor takes no interest in monitoring group progress, conflicts or contributions; and 2) student motivations are different in class than they are at work. In class, some students may be happy with doing "C" work while other students want to get an "A". This evaluation form is designed to address some of these issues.

1) Describe what you did to help the group succeed in your presentation? What were your duties?

2) Describe any problems you had working with your group. Time conflicts, personalities, other students' work ethic, or any other topics are acceptable to discuss.

3) What would you do to improve this experience for the second half of the semester?

4) If you could go back to the beginning of the semester and change any of the "rules-of-the-game", what would you change?

5) What do you see as the main benefits from the group projects we have been doing in discussion?

Figure 7 - Group evaluation form used at the end of each round of presentations.

A sample of some of the student comments after the first round of presentations is shown in Figure 8. The most common comments were that they got to see how other students solved the problems and got a different perspective from the ones presented in lecture. Learning this way is also the basis for the "thinking-aloud-pairs-problem-solving" strategies that have been in use for some time[20]. The students also thought that they were learning how to work in teams and how to communicate better with others, which were the main points of the activity. However, they went beyond that by also commenting that they were learning how to exploit the strengths of the different group members to finish the project with less difficulty.

After the final round of presentations, students were again asked to fill out the same group evaluation form. Samples of the comments from this round are also shown in Figure 8. The most common comments were very similar to those from the first round. However, more common this time was that they felt that just reading the problem statement was a good way for some students to start speaking in public. Other students commented that they were learning to resolve group conflicts without much difficulty.

Excitingly, there were several findings from this course activity that were not anticipated based upon previous experiences. Many of the students commented that this activity helped them to meet other people in the class whom they could contact for help when studying or solving homework problems. Also, half of the presentation problems were homework problems that were due the week after they were presented. This was viewed as a way of rewarding the students who participated, and to motivate others to come to discussion section. The students commented that this helped them start the homework earlier so they would be able to ask intelligent questions of the presenters and increase their homework scores. Other students said it was a good way to check their answers before handing in the homework.

Learn good ways from the other groups and want to do as good as they did (we will improve our abilities for the next time).
The class material is **re**presented and that helps clear any gaps in understanding.
My main benefit from the group projects is seeing how other people think about solving problems so I can use those techniques when I solve the problems.
Sometimes homework problems are presented.
We learn to appreciate others.
Motivation to do the homework early so I could check my answers before I turned in the assignment.
Working with others to define roles in group and to find strengths in the other members for either presenting the problem or understanding it.
Having someone other than the professor explain a concept, that way we get the same concept explained in alternative ways.
Getting an idea that you're not the only one who doesn't know what's going on.
Gives us a chance to present in front of an understanding audience before we have to in front of an unforgiving, critical audience.

Figure 8 - Sample comments from end of the project evaluations.

Students also mentioned several concerns about the group presentations on their final evaluations. The most common concern that the students had was that time conflicts made it difficult for everyone to meet at the same time. As previously mentioned, many of the students are under very severe time constraints already and cannot easily meet with their group. However, students came up with some good suggestions before the second round of presentations. Several groups decided to meet for a few minutes after class to delegate activities a week before their presentation instead of trying to meet at an unusual time. They then met after class again before their presentation to make sure everything was done and ready to go. This was a very effective use of time since it only took a few minutes to delegate tasks and the students would not do any redundant work or waste time watching someone else fulfill their group obligations.

Another concern that students had was that they felt certain group members did not contribute to their group's effort. Again, this is why group evaluations and assessments of what each group member did were collected. Also, notes were taken during the discussions about what each group member did during the presentation. Student grades were then adjusted up or down from the group average based on their individual contributions.

It was anticipated that more of the groups would encounter conflicts during the project. However, only two groups mentioned conflicts on their evaluations. These groups resolved their conflicts after we privately discussed some strategies for more effective communication and they were able to successfully complete their second presentations.

V. Future directions

No pilot project is perfect the first time it is implemented and this educational experiment is no exception. Students gave much feedback during the discussion sessions and in their written evaluations at the end of each round of presentations. Some comments from the students will be discussed here so that others interested in applying this discussion format to their own course can get a better glimpse of the student perspectives on where the project could be strengthened.

Several students thought it would be a good idea to make each student do a part of the presentation instead of allowing each group to determine who was presenting. Other students went farther and suggested that each student should have to do an individual presentation. Making each group member do a presentation is a fine idea, but time constraints in the course may not allow for individual presentations depending on the number of students enrolled in the course. Also, individual presentations would not have required the students to begin learning how to work in teams.

Other students said that they would like to see the perceived level of problem difficulty equalized for each group. This is a very valid comment and will need to be addressed in the future. Some problems were very short while other problems required more time than the twenty-minute period. Groups felt they had to fill the entire twenty-minute period even when their problem was easy while other groups ran out of time when they had not practiced their presentation. Some groups with longer problems, however, were prepared with a handout like the one in Figure 6 that described the final solution steps so the class would be able to see how to solve the problem even after they ran out of time.

Several students wanted to have the groups reformed after the first round of presentations so they would have more exposure to other students and their abilities. While this is a valid point, it was also important for the two groups that had internal conflicts to work together a second time. Making them work together the second time forced them to resolve their conflicts so they could complete their presentation successfully. Arguments for and against regrouping the students after the first round could certainly be made for each side, though.

One student suggested making completed discussion evaluation forms part of their final course grade. This would ensure that all students came to the discussion session each week rather than skipping the meeting time. This comment was made because some students did not come to the discussion session and there were no built in methods for including attendance into the final grades. This suggestion will be used next year. However, student names will be removed from all peer evaluations to eliminate concerns about personal backlash from honest feedback.

This initial implementation of teamwork-based communication projects in an introductory engineering course was highly successful. It was exciting to see that students were not just receiving the obvious benefits of practicing their presentation and teamwork skills. Instead, students felt that the structure of the presentation project and the format of the moderated discussions greatly helped them learn from each other's mistakes. It was also felt that the format of the initial activities prior to the start of the presentations helped them in meeting each other, creating support networks, and enabling them to succeed in the course.

VI. Conclusions

Integration of communication and teamwork building skills into an introductory engineering course had many benefits during this first attempt. First, students felt that they were able to meet their peers and create study groups more effectively than students in the course during previous years. Students also appreciated being exposed to methods of solving the problems other than those presented in lecture. In addition, students genuinely felt that they were becoming more proficient at oral communication, group conflict resolution, and in using individual group member strengths to finish their presentations. With the details from this work, it will be possible for other educators to integrate an activity like this one into their discussion sections. This will expose more students to the important communication and teamwork skills that they will need in order to succeed in their future careers.

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