



## **A Student-Led Approach to Promoting Teamwork in an Introductory Engineering Presentation**

**Dr. Christopher Leslie, New York University Polytechnic School of Engineering (formerly Polytechnic University)**

Christopher Leslie is a Lecturer of Science, Technology and Media Studies at the New York University Polytechnic School of Engineering in Brooklyn, New York, and he is codirector of the Science and Technology Studies program there. Dr. Leslie's research considers the cultural formations that surround technology, science, and media in the 19th- and 20th-century United States. He is the head writing consultant for the Introduction to Engineering and Design course, and also teaches courses in Science and Technology Studies such as the international history of the Internet, the history of science and race, and science fiction.

**Prof. Gunter W. Georgi, New York University Polytechnic School of Engineering**

Gunter W. Georgi, a registered Professional Engineer, is an Industry Professor at the New York University Polytechnic School of Engineering in Brooklyn, New York. Prof. Georgi is the course director for the Introduction to Engineering and Design course. He received his B.S. from Cooper Union and his M.S. and professional M.E. degrees from Columbia University. He has worked many years in the aerospace industry in design, analysis, and management functions. His most challenging task was the responsibility for the Thermal Mission Analysis of the Lunar Module from Project Apollo.

**Miss Alyssa Marie D'Apice, New York University Polytechnic School of Engineering**

Alyssa D'Apice is a third year undergraduate student pursuing a Bachelor of Science in Chemical and Bio-molecular engineering at the New York University Polytechnic School of Engineering in Brooklyn, New York. She is one of four head teaching assistants for the Introduction to Engineering and Design course where she manages over 100 student workers, making sure that the course moves seamlessly. While on campus, Alyssa has participated in varsity basketball, volleyball, and softball and during her freshman year she earned the basketball Rookie of the Year award for her conference.

## **A Student-Led Approach to Promoting Teamwork in an Introductory Engineering Presentation**

At the Polytechnic School of Engineering of New York University, formerly known as Polytechnic University, a first-year required course, Introduction to Engineering and Design, has been a core part of the curriculum for many years. As part of this course, student teams are expected to solve one of eight independent semester-long projects by the end of the term. For many years, non-completion of projects or personality problems within teams was rare – perhaps one out of a hundred per semester. Recently, more teams have been having trouble, and the course has been growing as well. For instance, we had 15 cases of non-completion in Fall 2013 and 11 cases in Spring 2014. In our summer 2014 planning meetings, we decided that something needed to be done to address teamwork as a learnable skill because it is such an integral part of engineering.

In our opinion, the higher rate of non-completion was mostly due to current students having difficulties with communicating face-to-face; the skill set required to discuss how to jointly do their projects is sorely lacking in today's undergraduates. It may be in part due to the changing nature of today's digital students. As well, due to our school's expanded number of first-year admissions, perhaps our changing demographics have led to a change in our students' background and preparation. Regardless, a sizeable number of our students do not realize that engineering is accomplished by teams and that teamwork is a skill that they can learn. More specifically, they do not recognize that their team projects are in trouble until it is too late. Even when they realize there is a problem, they think that it is a failure of their teammates rather than for them to manage a team effectively so that each team member's best qualities are manifest.

At last year's ASEE meeting in Indianapolis, teamwork was the subject of many papers. The presentation from the University of Michigan (UM) described a fresh approach; their Educational Theatre Company's "Off Course" skit showed students what to do and not to do in teams. As the UM team discusses in their white paper, research on teamwork pedagogy suggests that educators need to make teamwork an explicit part of their classroom. Their group of undergraduate actors who are trained in making educational theater performances provided a dramatic presentation of "common team dilemmas" and made an effort to explore how diversity has value in teams<sup>1</sup>. In the presentation, four undergraduate students pretend to be working on a project and each takes a role: a shy student, an overachiever, a slacker. In addition, the drama illustrates gender dynamics and project management skills. In an interactive portion of the program, students in the class ask questions of the performers, who respond while remaining in character to reveal "individual motivations, actions, and decision-making processes."<sup>2</sup> As can be seen in the video of the performance, UM creates a vivid portrait of the challenges involved in teamwork.

Although one might be skeptical about the results of just one intervention in a student's attitude toward teamwork, it is important to note that the UM group added the teamwork unit to a course that already had a strong teamwork component. Thus, the skit served as an introduction to the experience of teamwork in the course. Due to their interest in assessment, the UM group introduced only one half of the class to the skit, thus creating a control group. The group that worked with the skit was found at the end of the course to significantly value diversity in teams

and identified the importance of taking a specific role on a project. Students who saw the skit were also shown to have more strategies for resolving teamwork problems, such as in communication, than those who did not see the skit.

Inspired by this work, the faculty and teaching assistants affiliated with our introductory course used this “skit” technique to develop a program in the one-hour lecture slot for all students in all sections of the course. As the instructors at UM note, not all faculty have access to an on-campus educational theater group. Even so, we were inspired enough to make our own presentation. Our introduction to engineering course is divided into a portion that is team-based, a weekly lecture, and a portion that is conducted in a more traditional laboratory-and-recitation format. The course’s instructional team itself is team-based, which means we value the power of teams at the same time that we incorporate ideas from a wide range of sources. It seemed to us that even an effort that was not supported by an educational theater group would be beneficial to initiating a conversation about teamwork.

## **A. Literature Review**

Although much of the published literature deals with establishing effective grading systems for teamwork, tracking the team’s efforts, and facilitating the creation of groups, our course has already addressed these issues to our satisfaction. Therefore, we were most intrigued by the UM group’s approach to teamwork. Many of our students already seem to have a negative attitude about team-based exercises because many of them have served on teams before. We knew that one of our tasks was to initiate a conversation among students, TAs, and faculty about how to make teams better. In addition, we wanted to demonstrate the professional imperative that leads us to adopt a teamwork pedagogy.

The Polytechnic School of Engineering is, of course, not alone in its effort to inculcate positive teamwork experiences in their students. We, as others, have found approaches to teamwork face challenges. Before they reach college, students are exposed to a wide variety of experiences of teamwork, from classes to sports, clubs and performance organizations.<sup>3</sup> Furthermore, as has been discussed elsewhere, the reliance on teaching assistants (TAs) means that they have a vital role in the delivery of the course objectives.<sup>4</sup>

We have developed our course over many years, incorporating best practices from published literature, conferences like the ASEE, and first-hand knowledge. Students in each section form into groups and tackle one of several projects that have specific achievement goals (one might say that they have well-defined objectives<sup>5</sup>). Their first team-based milestone is really a team-building exercise that requires them to prepare a project statement, plan their work, and divide the responsibilities (one might call this self-organizing<sup>5</sup>; another would note that this helps students to recognize their “positive interdependence”<sup>6</sup>). As the teams work on their design projects, they make two other progress reports to their professor (one might call this “group processing”<sup>6</sup>). In addition to regular check-ins with the course instructor, teams are monitored in their progress toward meeting the project requirements by standardized benchmarks, and the failure to pass a benchmark at the required time gives both the students and the instructor a warning that something is amiss. Finally, each group can avail itself of the help of teaching assistants during open hours in the model shop. Therefore, each team is well supported in their

effort to complete their independent project by the deadline. We measure this by the number of teams who complete the basic requirements of the project by the deadline (in the terminology of the course, how many teams “commission” their projects on time).

Considering that teamwork is stressed in our course, we have returned to the question of how to support students in developing this skill. Our course always, in our opinion, is under development and we regularly scrutinize each course component for its effectiveness. Over the years, we have noted that teamwork is a particularly difficult aspect to improve, and we are not alone in this regard. For one thing, soft skills like teamwork may take several courses to develop,<sup>7</sup> and so our effort in this course may only be the beginning of a trajectory that results in a successful engineer. Incorporating teamwork in the first year of college also is challenging because it runs counter to students’ previous experience. According to one researcher, the individualistic nature of high-school education, which rewards students for their performance in individual assessments, like taking tests and presenting oral reports, does not fit in with the expectation of working on a team.<sup>8</sup> Teaching students to work on teams is counter to this training, they write, so “without a clear explanation of the redefinition of what makes a good student or engineer, they will continue to perform to the traditional criteria.” Their solution was to develop an academic minor, but this curricular innovation would not necessarily improve the first-year experience.

As pointed out by the UM team, students typically have not received specific guidance on how to be a good team member, and they lack strategies for addressing common team dilemmas. It is the instructor’s responsibility to explain to students why teamwork is being used in the class and to help students develop the skills needed to be good team contributors.<sup>2</sup> Simply including teamwork in a syllabus does not mean it will be successful, note other researchers. “The assumption is that experience is the best teacher, that students when given sufficient opportunity to participate in team activities will learn how to be effective team members on their own.”<sup>5</sup> The authors continue, pointing out that negative teamwork experiences may impact student attitudes toward team-based projects in the future. Because team efforts are industry norms, engineering coursework should include lessons in teamwork, “in any class involving analysis, design, implementation, and testing.” Their solution is different from UM: assessing students fairly by using Google groups to document team members’ efforts.

## **B. Methodology**

Our effort differed from UM’s effort in several ways. For one, we selected current teaching assistants (TAs) for the skit. These are students (primarily) in engineering disciplines who volunteered to be a part of the presentation. Through a brief training process, we engaged a group of six TAs to detail a variety of student personalities and backgrounds. Building on our diverse student body, the TAs incorporated challenges that face all groups of students (both international and domestic, male and female, etc.) They then created two before-and-after style scenarios regarding teamwork, scheduling, and communication.

On the day of the lecture, the presentations were introduced by a faculty member from our Science and Technology Studies major, who put the theme of teamwork into the context of the history of science and technology. The students were introduced to multiple projects that could

not have happened without the assembly and use of a team. Everything from World War II to the Apollo mission and the Curiosity rover was discussed, establishing a base for why teamwork is so important not just in this course, but in the practice of engineering as well. Throughout this introduction, the origin of the multidisciplinary team in what historians sometimes call big science was stressed, and examples were drawn to emphasize the point. The importance that teamwork has in engineering was also stressed by showing its place in ABET's criteria. Then, our TAs presented examples of bad teams, discussed what had gone wrong and strategies to improve, and finally made presentations of good teams.

### ***1. Preparation for Fall 2014***

Fall 2014 was the first trial run with the teamwork skit, causing much more thought and planning to go into this process. Multiple meetings were held across several weeks and included four very important steps that were critical to the success of the skit: building, brainstorming, planning, and testing. Throughout this entire process, the faculty member was involved, critiquing and changing aspects of each step to make this skit a success. Each step of the process is described in greater detail below.

#### *Step 1: Building*

In order for a team to be successful, there must first be a group of people ready to work toward a common goal; this skit was no different. The first step of this process was to gather six teaching assistants who were willing to help teach students the important lesson of teamwork while also being comfortable enough to act on stage in front of all the first-year students taking the course.

A variety of different teaching assistants were gathered based on interest and only six were selected. These six teaching assistants had different backgrounds and personalities, perfect for representing the diversity of a typical student team within the course. One teaching assistant was from the New York City area while another was an international student with a heavy accent. We also picked teaching assistants with a variety of different personalities from being laid back to shy to outright friendly. All of these personalities and backgrounds as well as educational majors were taken into consideration when building two separate teams for the skit. These two separate teams consisted of three different people who were believed to bring out the most in one another. Once these two teams were chosen, the brainstorming phase began.

#### *Step 2: Brainstorming*

After creating a solid foundation for the two separate teams, a meeting was called for all six teaching assistants and the faculty to attend. The idea of the meeting was to discuss and come up with many different problems that occurred in the past or could occur in the future when working in teams, whether it was a personal issue or a work-related one. Many of the problems discussed were not just personal experiences, but also issues that these teaching assistants have observed throughout previous semesters. During the meeting, every teaching assistant was given a chance to speak about themselves, as well as anything they have seen in their lives regarding teamwork.

Many different ideas were brought up and a record of all of the responses was kept throughout the meeting. Some ideas were commanding enough to keep to one personality: a go-getter, know-it-all student who has a 4.0 grade point average and will do whatever it takes to get a great grade. Other ideas were combined with additional ones to make the personality larger: for instance, we incorporated an international student who depicted a student with a thick accent that made him difficult to understand and so was too shy to speak up and make his opinions heard.

These personalities are practical and exist in both the students taking the course and in the real world with professionals, which is why they were chosen to use in the teamwork skit. Having ideas coming from undergraduate teaching assistants who have both taken classes that require teamwork and teach a class that require students to work in teams made them all the more ideal to teach first-year students how to deal with common team problems.

### *Step 3: Planning*

At the end of the brainstorming meeting, the faculty helped the TAs select personae that were felt best suited for each of their personalities. Each persona thus was optimized as to how well the teaching assistant felt he or she could play the part. Because the six teaching assistants were not professional actors and actresses, giving them a persona that fit well with their own helped them feel more comfortable on stage. A friendly, outgoing teaching assistant seemed more willing to act out a personality that required him/her to be more arrogant than a teaching assistant who was more reserved. After each persona was assigned, the two teams were asked to briefly speak with their team and discuss ideas for how they would like to act out the skit.

Each team had its own separate meeting where the details of the skit were discussed and written out. All of the group members, as well as some faculty, were involved. First, a specific scenario was chosen. There were multiple scenarios that could have been chosen because there are multiple times throughout the semester when student teams meet, give presentations concerning their projects, and work on their projects together. For the two different groups, different scenarios were chosen to remind the students that at any point within the semester, teamwork can be a major challenge to overcome.

Second, all members of the meeting participated in giving their input when the dialog was being produced. During the skit, there were two different performances by each group. The first performance was a demonstration of poor teamwork while the second was of good teamwork and communication. Dialog for the poor teamwork skit was discussed first. This dialog was a little more exaggerated to make the students aware that some people think a certain way and are not afraid to let everyone know. For example, there have been instances in the past where women were not allowed to touch the project because a group member felt that women are not suitable engineers. Although this is not the most common problem seen in past semesters, the students are exposed to it early on in the semester, hopefully allowing the female undergraduates to be more aware of situations that may occur either in the semester or in the future.

After the dialog for the bad teamwork skit was created, it was time for the dialog to be altered for the good teamwork skit. In the good teamwork skit, the scenario was very similar to the bad teamwork, except that the dialog was changed to show the students how they could handle some

of the situations. With the skit, it was important to not only show the students the problems they should be aware of when working with teams, but also to give them at least one step or solution to tackling a problem. Although the solution may not work for everyone, it helped educate the students on how to approach a problem and who they can speak to if they cannot handle the situation on their own. The planning phase was done for both teams during separate meetings that took place a week prior to the day of the presentation.

#### *Step 4: Rehearsing*

The final step for this process was the testing phase, where the two groups practiced both their good and poor teamwork scenarios. This allowed the teaching assistants to be more comfortable with each other on stage. Also, it allowed them to work with props to make the skit more realistic and to help guide the students in the right direction. These props included white boards, notebooks, computers, projects, etc. This testing occurred a few days prior to the presentation date when all of the group members were free to rehearse.

A lot of time went into the preparation of the teamwork skit, not only to educate the students on teamwork, but also to help educate the teaching assistants. TAs play a vital role in the course and many of them observe students every step of the way during their semester long design project, either watching them work on their projects or making a team presentation on their progress. Allowing the students to see teaching assistants and hear some of their thoughts and experiences with teamwork created an outlet for the students and allowed them to go to teaching assistants when they had problems later on in the semester. Many of the teaching assistants had been through issues not only in some of the same classes as many first-year students, but also in higher level classes; their inputs helped create a teamwork skit that was not only educational, but one that created a friendly environment where the students feel comfortable asking for assistance.

## ***2. Preparation for Spring 2015***

Planning for the spring teamwork skit proceeded as before. Unfortunately, several of the skit team members were unable to participate due to a time conflict with their spring courses. However, we were able to find new volunteers to take their place. Because about one-half of the team was new, we engaged in a full planning process after discussing the results of the first skit. The teams decided to keep some of the elements from the previous semester's group but also innovated their own personas and situations.

In addition to the new content, a change for Spring 2015 was the use of interactive technology. Collaborating with our center for Faculty Innovations in Teaching and Learning, we designed a series of clicker questions for use on the day of the skit. All students responded to a few questions before the teamwork presentation, which our faculty member used as part of his discussion about teamwork, and then those results were used at the end of the lecture period to discuss the results.

## C. Assessment

### 1. Fall 2014 Skit

The results of the Fall 2014 skit, our first effort, can be summarized in two ways. First is the number of teams that did not complete their projects on time. Although we had hoped to dramatically turn around the trend of non-completion, we were displeased that we did not see a significant change. As can be seen in Figure 1, we can say the course grew greatly and teamwork problems did not get worse. (Note that spring course enrollments are generally smaller than the fall, but Fall 2014 was much bigger than normal.)

Another way we were able to assess the teamwork skit's effectiveness was in our end-of-semester survey. We modified a question on the survey about teamwork to directly ask about the skit (in this assessment, we described the presentation as a *sketch*). Those who commented stated that they found the skit amusing or even "silly." Interestingly, some thought that the skit was unhelpful, but went on to explain something from the skit (i.e., one must monitor the team's progress regularly). One wrote, "Teamwork sketch? What is that?" and another pointed out, "I also doubt anyone who would make a bad teammate saw this presentation and realized the error of their ways." Others were obviously confused by our terminology of *sketch*, thinking that we referred to the team's initial sketch of their design, which is required for the first project milestone. This led us to use the term *skit* going forward.

<i>Spring 2014 (before skit)</i>		<i>Fall 2014 (first skit implementation)</i>	
Total number of students	159	Total number of students	324
Commissioned	126	Commissioned	256
Did not commission	33	Did not commission	68
Percentage commissioned	79.25%	Percentage commissioned	79.01%

Figure 1: In the semester before the skit was implemented, the percentage of students who commissioned their projects (completed the essential components of their project) was about 80%. This percentage remained about the same in the first semester of the skit, but noting that the size of the course more than doubled with an influx of new students, the fact that the commission rate did not decrease can be seen as a success.

Others were more positive. One student, perhaps taking a cue from our TAs' jokes, wrote:

Communication and initiation of conversation [were] very important. It was comedic and it told me what to look out for in a team environment. I found that a team really needs to communicate and work together to function.



This student, taking the communication failures presented by the TAs to heart, went forward with his team project to make sure to communicate and use humor to do so. Another student wrote:

I think I learned how to divide up the work rather than doing everything on my own – and I also learned how to deal with people who chose not to listen. Learning how to communicate with teammates and organize a schedule with meetings and deadlines was the most useful [thing] I learn[ed] from this course.

This student, like others, realized that teamwork is an integral, although difficult, part of the engineering environment.

The assessment of the Fall 2014 skit led us to think slightly differently about the Spring 2015 presentation. First, we realized that our effort to engage the students with humor was not entirely successful, and in our planning for this new skit we decided to decrease the amount of humor slightly and instead add more specific suggestions on how to make a team function. Second, we realized that waiting until the end of the semester to gauge student response to the teamwork skit was not useful. We determined that using a source of immediate feedback, like clickers, would be helpful.

## 2. Spring 2015 Skit

For the spring semester, we decided to use clickers to gauge student response to the presentation. Although the UM method of using a control group was scientifically more rigorous, we felt as if our students benefitted from the presentation and did not want to cordon off a group.

Our first question, regarding previous exposure to team-based assignments, revealed to us that almost all of our students thought they had significant exposure to teamwork (see Figure 2).

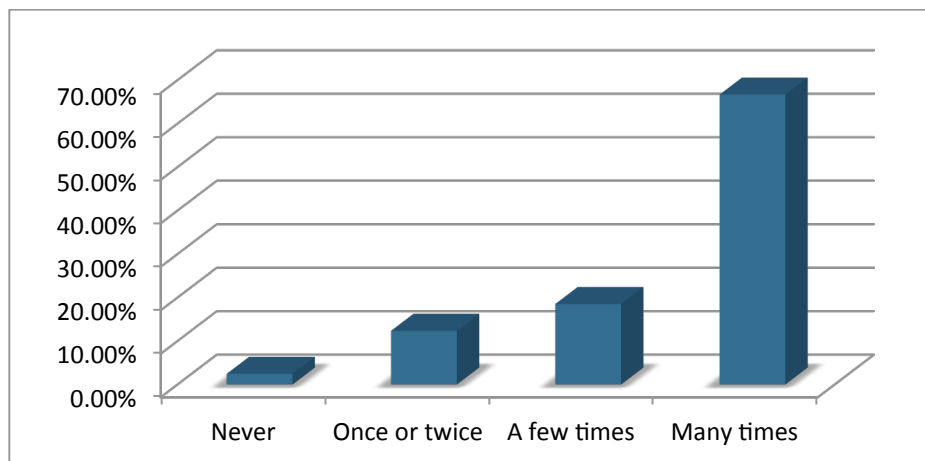


Figure 2: During the presentation, students were asked, “How Many Times Have You Completed a Team School Project?” Students were left to their own definitions, which may lead to a wide variety of responses.<sup>3</sup> Nevertheless, the

large number of first-year students who already believe they are skilled at working on teams makes teaching about teamwork a challenge.

We did expect a significant number of students to indicate that they had worked on projects in teams before, and if we had additional time and experience for this assessment, we could have drilled down into this issue more thoroughly. One might expect, for instance, that what students classify as teamwork is more akin to working in groups, even though we think of teamwork as being a interdisciplinary group that works on an independent project together. In anticipation of this challenge, however, our second question asked students to tell us why teamwork is so prevalent. As shown in Figure 3, less than one-half of our students believed that it was a professional skill, while exactly 50% of our students believed that teamwork had some sort of institutional expediency (social skills, saving money, and teaching each other). Given that our motivation in incorporating teamwork into the introductory course was to prepare students for the world of team-based engineering, it was clear to us that we needed to help students rethink their assumptions about working together.

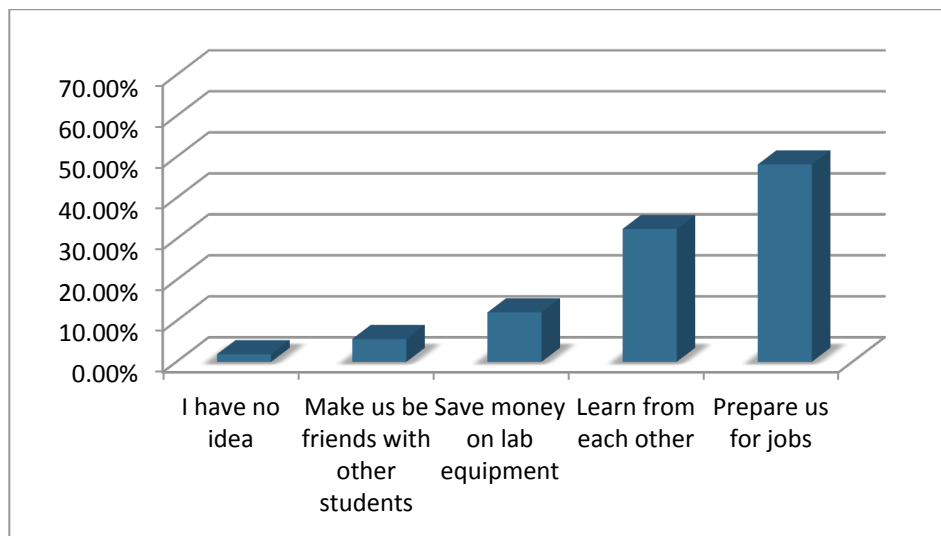


Figure 3: Another issue regarding teaching teamwork is that not all students see teamwork tied to professionalization. When asked, “In Your Opinion, Why Are Teamwork Projects Required?”, less than half of students considered that teamwork is a necessary job skill.

Our next question sought to gauge the impact of our teamwork skits. As seen in Figure 4, we asked our audience what they would do if their team starts to encounter difficulty. Anecdotally, we hear from students that they do not like working on teams because they end up doing all of the team’s work; this is reflected in the pre-skit response of 30% of our students, who responded that they would simply take over the project. About 15% of the students before the skit said they would talk to the teacher or stop working. After the skits, a full 15% more of the class said they would call a team meeting if they noticed they were having trouble, equaling a 15% drop in the number of students who said they would take over the project. The number of students who said they would talk to the teacher or stop working stayed roughly the same, at 17%, even though there was a notable uptick in the number of students who indicated they would stop working.

These results were informally demonstrated to us approximately two weeks after the teamwork skit. In some cases, students have been observed joking with their team members, characterizing their actions as bad team members. In general, we have seen a willingness to make the team work. For instance, a student approached the professor, discussing how his other team member had not shown up to any of the classes or team meetings he was trying to put together. The student said that he attempted multiple times to get in contact with the other student but unfortunately he was unable to do so and knew from the teamwork skit that it was possible to talk to a faculty member about the issue. This student’s recognition of the problem early on in the semester stemmed from the ideas conveyed to the students in the teamwork skit and demonstrated that, to at least one student, the information and the skit was meaningful and helpful.

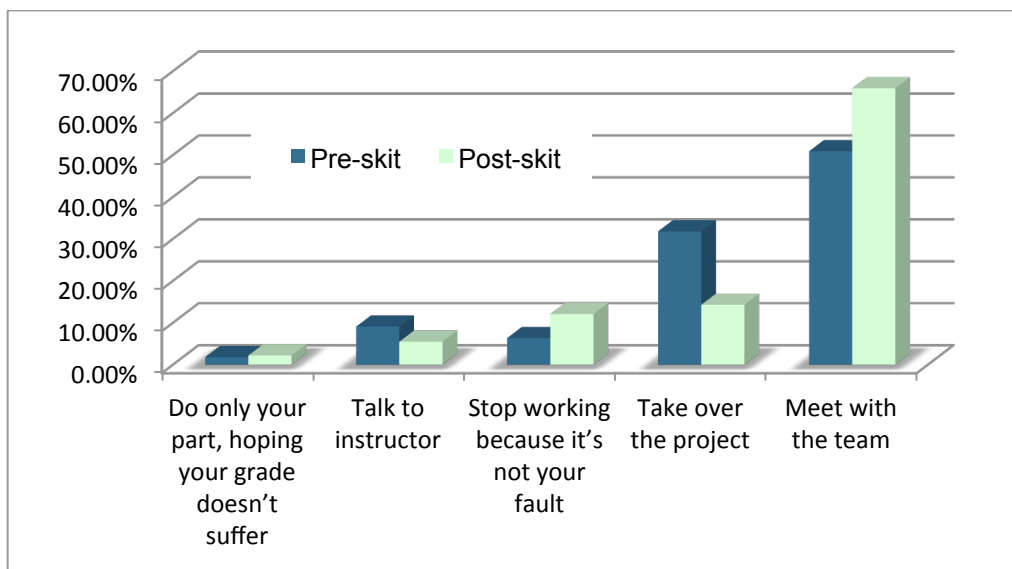


Figure 4: A definite change due to the presentation was noticed in our before/after question, “What Do You Do If a Project Team Starts to Fall Apart?” The number of students who felt they would take over a project when teamwork failed was halved, with a corresponding increase in the number of students who asserted they would call a team meeting.

This article went to press too soon to determine the number of teams with completion problems in the spring 2015 semester. As well, the end-of-semester assessment was not ready in time for publication.

#### D. Conclusion

At the Polytechnic School of Engineering at New York University, we have required a first-year course that introduces engineering for many years, and this has always included a team component. The University of Michigan team was successful in using a teamwork skit in its course, and they presented a challenge to other schools that do not have an undergraduate acting

troupe. We were successful in creating a low-budget version of a skit that introduced teamwork skills by using our teaching assistants, who are undergraduate engineering students.

This group found the UM approach to teamwork lessons beneficial. Despite the fact that more students than ever are introduced to the fundamentals of engineering in K-12 programs, our experience has been that recent students do not think of teamwork as a part of engineering that must be learned as a skill; instead, they blame team failures on individual personalities rather than the failure of managing their team. Like UM, we found that explicitly addressing how teams can be built helped to increase the awareness of why teamwork is included in the course and enhanced student response to the existing teamwork component of the course.

Unlike UM, however, we did not have access to an on-campus theater group. As the UM instructors had surmised, it is possible for a department without acting resources to mount a teamwork skit effectively. Although our effort may not have been as professional as another skit would have been, through the use of a constrained format for brainstorming and presentation and the good spirits of a trained TA team, we were able to approximate their effort and initiate a conversation about teamwork even though we did not have an educational theater resource at our institution.

Our in-house approach had an unexpected benefit for our instructional team. Our team members, by using their own experience, were able to bring to life the presentation. In the question and answer period, especially, current TAs – instructional staff that students are likely to encounter – gave their own insights and opinions into what they saw as the challenges and opportunities of teamwork. In this way, the peer relationship was an asset in gaining students' attention and bringing insights to them on what they can do to succeed in this important foundational course. This interaction further allowed the students to become more comfortable with the teaching assistants, making the students more likely to approach the teaching assistants with any problems or concerns about their team. Furthermore, it served to bring attention to the TAs how they can assist the students they work with in teamwork. In this way, the in-house nature of our effort led to a pedagogical improvement.

We were pleased to see the shift in student attitudes before and after the presentation, and more assessment of this type could be incorporated. An unexpected result of this investigation was our finding that only about half of students saw teamwork as an important skill for professional engineers. In a worse-case scenario, if one of the students who does not value teamwork is a part of every team, each group could suffer. This is not too far-fetched given that, in our course, many teams are made up of three individuals. Although efforts to grade teamwork fairly and accurately may succeed in forcing students because they face penalties for noncompliance, a carrot-based approach such as ours – leading the students to engage with teamwork skills because we tie them to professional outcomes – may have merit as well. This finding suggests that additional research is warranted.

We plan to continue to use a teamwork skit in the future and gather more data on student reactions to the skit and even the preconceptions that might inhibit their willingness to serve on teams. We expect to provide an update on our efforts at ASEE. We also are on the lookout for

more data on the effect of the digital age on teamwork; there appears to be a scarcity of research on this subject.

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