AC 2007-1241: DRAMATIZING ENGINEERING EDUCATION: THE PERFORMANCE OF TEAMWORK

April Kedrowicz, University of Utah

April Kedrowicz is the Director of the Center for Engineering Leadership at the University of Utah. Dr. Kedrowicz received her BS and MA degrees in Organizational Communication from the University of Wisconsin-Stevens Point and her Ph.D. in Communication from the University of Utah.

Bob Nelson, University of Utah

Bob Nelson is the Chair of the Department of Theatre at the University of Utah.

Dramatizing Engineering Education: The Performance of Teamwork

Abstract

Engineering education is now characterized by innovative approaches to instruction. Collaboration between (often disparate) disciplines is becoming increasingly common to meet the educational needs of engineering undergraduates. ABET's EC 2000 has shifted the focus from technical educational outcomes to encompass professional educational outcomes, including the ability to communicate and function effectively on multidisciplinary teams. As a result, greater emphasis is placed on teaching students the teamwork principles and associated communication competencies necessary for a healthy and productive team experience. Interestingly, teamwork pedagogy has not occupied a prominent position in the engineering education literature, despite this emphasis on teaming in the classroom and industry. The purpose of this paper is to highlight one specific, innovative approach to teaming instruction that requires collaboration from faculty in three different disciplines, namely, communication, drama, and engineering. Representatives from each department work with undergraduate engineering students to teach them team dynamics through writing of vignettes appropriate for the particular curriculum, and through performance, employing a range of techniques such as role-play, role switching, alter-egoing, etc. A description of this educational approach is provided, followed by a summary of students' reactions to the instruction. Finally, faculty members' reflect on their experience working as part of a multidisciplinary team and offer recommendations for implementation.

Background

The field of engineering demands collaboration to solve today's complex problems. Gone are the days of working alone in a lab. Today's engineer needs to be able to function as a productive team member, and to accomplish this objective, the engineer needs to be a competent communicator. As a result, much of the focus of communication instruction within the engineering disciplines emphasizes effective informal communication within teams. In fact, a greater focus has been placed on "teaming" in the engineering education literature.

Engineering teaming research, in general, encompasses the following areas: (a) cooperative learning, (b) specific examples of using teams in the classroom, (c) the impact of gender (and other demographic variables) on team productivity, (d) common teaming deficiencies, and (e) approaches for assessing teamwork (i.e. grading or evaluating team projects). Although this literature is a valuable resource for instructors of teamwork, it fails to address team pedagogy. That is, of the essays which afford mention of team communication as an important aspect of effective professional development, none go on to explain how to *teach* students effective teamwork principles for the benefit of the project and team member relationships.[i] Often, the unfortunate reality of teamwork in the classroom (stemming from a lack of productive team

[i] For an exception, see Seat, E. and Lord, S. M., "Enabling Effective Engineering Teams: A Program for Teaching Interaction Skills," *Journal of Engineering Education, Oct. 1999,* pp. 385-390.

pedagogy) is that students find themselves in patterns of unproductive team communication that can lead to conflicts. What is more, they may be ill-equipped to manage or resolve those resulting conflicts, and thus find themselves inadequately prepared to handle team issues in the workplace.[1-2]

The Department of Mechanical Engineering at a large Western University recently adopted a formalized, integrated communication and engineering curriculum. Engineering undergraduates are required to demonstrate competence in communication related to team processes and to accomplish this goal, they receive direct instruction in the classroom that assists them with their semester-long, team (design) projects, culminating in project demonstrations, final written design projects, and formal team presentations.

Through interacting with students about team dynamics for several semesters, it became apparent that the perceptions engineering students have about teamwork instruction is quite different from their perceptions about formal oral communication and writing instruction. For example, while the students perceived the oral and written communication instruction to be extremely valuable and well received at all levels of the curriculum, their ratings of the effectiveness of teamwork instruction were consistently lower and/or even devalued. As such, our goal in conducting this project was to employ a unique pedagogical approach to teamwork instruction, utilizing a collaborative, multidisciplinary instructional format.

In this paper, we describe the teaming instruction that was employed, as well as provide a summary of student reactions to the instruction. Finally, we provide reflections from the faculty members involved, followed by recommendations for future iterations of teamwork instruction.

Teamwork Pedagogy

Traditionally, the engineering teamwork literature has emphasized the importance of teaming to engineering problem solving and project completion, as well as highlighted important teamwork principles such as team formation, roles and norms, conflict resolution, and characteristics of effective teams.[3-6] Too often, beyond introducing/explaining these concepts, a discussion of teamwork instruction provides mere mention to “putting students in teams” and providing them with a project to complete. The assumption underlying this approach is that students will “learn by doing” simply because they know these concepts and/or are a part of a project team. In fact, this attitude is prevalent, even among students. This assumption has resulted in minimal discussion of teamwork pedagogy in the literature, and arguably, minimal instructional time devoted to the *teaching* of teamwork principles.

One approach that has been mentioned briefly in the literature is the use of role play as a way to teach interaction skills (e.g. Seat & Lord; Sharnnia, Glenda, & Odis Griffin, 2006). Role playing occurs when students are assigned a particular character to portray, and then improvise their interaction in a given scenario.[9] In other words, they “act the part.” The advantages of role playing for teaching interpersonal and communication skills are numerous. It promotes the development of specific skills through allowing students to try new behaviors in a low anxiety situation and receive feedback. It also enables students to experience how others might feel in a certain situation; it promotes perspective taking.[10]

Although role playing affords many advantages and has the potential to improve students' learning of effective teamwork principles that will ultimately improve their teaming experience and end product, it is often not taken seriously when implemented in the engineering classroom. As a result, any benefit that might be derived is likely lost, due to the lack of serious effort put into the exercise. To combat this, we enlisted the help of a faculty member from the Department of Theatre to conduct the role play sessions and assist with the debriefing process.

Our interest in this project, then, was to experiment with an innovative approach to teamwork instruction in the engineering classroom. Specifically, we were interested in incorporating a collaborative, integrated approach to teamwork instruction that utilized role play, role reversal, and alter-egoing to teach students principles of effective team communication. This innovative approach relied on the expertise of individuals from drama, communication, and engineering. The remainder of this paper explains our instructional techniques, student and faculty reactions to this experience, as well as recommendations for future iterations of this and similar approaches to instruction.

Previous Teamwork Instruction and Current Collaboration

This project was part of on-going work conducted by the CLEAR (Communication, Leadership, Ethics, and Research) Program in the College of Engineering at a large Western University. Since 1996, individuals from the Department of Communication and the University Writing Program have provided instructional support in communication on an as needed, sometimes informal basis. In 2003, thanks to the generous support from the William and Flora Hewlett Foundation, the CLEAR Program was able to formalize communication instruction and develop a four-year communication integration plan that includes curriculum development, direct instruction in the classroom, and student and faculty consultations, as well as researching communication and engineering pedagogy.

At the end of each semester, course evaluations are distributed in every course with formalized CLEAR instruction. These evaluations, developed by the communication instructors, with assistance from the program director, are designed to elicit information about the effectiveness of communication (oral, written, teamwork) instruction, including strengths of CLEAR collaboration and recommendations for improvement. The communication instructors and program director read all of the evaluations and use students' feedback to make any necessary modifications to instruction, including both content and instructional approach.

Communication instructors have pointed out the problems with previous approaches to teamwork instruction. Although instruction varied slightly each semester in response to student and faculty feedback, teaming instruction generally took the form of a lecture/discussion of specific teamwork principles (i.e. team roles and norms, team formation, meeting management, conflict resolution, cohesiveness, task-process balance) followed by an in-class team activity and debrief session. For example, when discussing task-process balance, we engaged the students in a discussion of key teamwork concepts, followed by the "build a tower" exercise. Students were asked to construct a tower out of toothpicks and gumdrops in accordance with certain constraints (i.e. no talking, use of only one hand, etc.) Similarly, when discussing roles and norms, students

were asked to complete a survey and discuss the results with their teammates, culminating in a team contract. Arguably, these as well as other teamwork activities have utility for the students. The problem, however, was in stimulating excitement in the students and in getting them to understand the transferability of the competencies they were developing. Our concerns were echoed by the students. Previous course evaluation data suggest that students are dissatisfied with teamwork instruction. Whereas students generally respond positively to oral and written communication instruction and exercises in all of their engineering classes, students' perceptions of the usefulness of CLEAR teaming instruction to their future as professional engineers is generally less positive. As a result, we began to generate ideas for how to improve teamwork instruction, with the hope that curricular and content changes would result in more favorable utility and evaluations.

Following this, the new instructional format, utilizing the expertise from faculty in three different disciplines, was born and collaboration began in Spring 2007. Specifically, the engineering faculty member provided the context-specific engineering case(s) that were to be the basis for the role play, role reversal, and alter-egoing instructional techniques. The communication faculty member provided the teamwork information and selected key communicative skills and principles to be emphasized in each case. Finally, the theatre faculty member led the students in the interactive activities and coached them as they acted out specific characters. All three faculty members collaborated during the debrief session upon completion of each exercise.

This experimental instruction took the form of two role plays that were conducted in the freshman Mechanical Engineering course. The role play scenarios (see Appendices A and B) were developed by the communication faculty member, with the help of the engineering faculty member, who provided the contextual engineering information. The scenarios were studied by the theatre professor and any confusion was clarified by the engineering and communication professors. Students were solicited for participation in class and were told they would receive extra credit for their participation.

Eight students (two groups of four) agreed to participate. To prepare them for the role play activity in class, the students were required to attend two coaching sessions outside of class with the theatre professor. During these sessions, students acted out several different case studies while occupying the various roles outlined in the two engineering scenarios. The idea was to have them practice various roles in situations similar to (but not exactly) the role play scenarios they would act out in class. A portion of the coaching sessions was devoted to discussion about the various roles, including how students felt portraying the different characters and what they learned about interpersonal communication as a result of the exercises. Finally, students were provided with the role play scenarios they would act out in class and were assigned particular characters.

The two groups then acted out the engineering role play scenarios in front of the class. Each role play lasted ten minutes, after which time, the class and the role play participants discussed key communication and teamwork components. The communication instructor facilitated the discussion, with input from the engineering professor.

Student Feedback

Immediately upon completion of this in-class exercise, we collected data to assess students' reactions to the collaborative, interactive teamwork instruction. Specifically, surveys were distributed (see Appendix C) that combined both forced choice, likert-type (1-5) scale questions (subject to statistical analysis) and open-ended questions that were coded for emergent categories and themes according to the grounded theory approach to data analysis.[11]

Thirty-three students completed the survey. Findings indicate that the majority of students viewed the exercise positively (79%). Moreover, the data indicate that the majority of students both saw the applicability of the information presented (M=3.94, Md=4) and were more satisfied with this teamwork activity than previous approaches to teamwork instruction (M=4.03, Md=4). In addition, qualitative data suggests that all of the students believe they will utilize what they learned in the future as these comments suggest: "I will be more observant and actively deal with communication problems within our teams as they surface" and "I will be more attentive and aware of situations and will resolve conflict as it arises." Moreover, all but three students would recommend similar activities for other mechanical engineering courses so students can learn about productive team communication in an open forum: "We may be experiencing a similar issue in the future, and this exercise presented possible solutions for the problems" and "This was a fun, interactive active that opened my eyes to how things can happen in teams."

In short, students' reactions to this exercise were positive, regardless of whether they were role play participants or observers. They learned about how to productively resolve conflict in teams, the importance of perspective taking, and ways for dealing with people who are domineering, passive, etc. They believe this information is applicable and will be useful to them both in future classes and in the workplace, and they recommend this and similar activities to be conducted in other mechanical engineering courses.

Faculty Reflection

In addition to student feedback, we reflected on our experiences working as members of a multidisciplinary instructional team in a core mechanical engineering course. We feel confident that we developed a teamwork activity that will truly benefit the students and promote productive communication within their teams. The expertise of the theatre faculty member brought credibility to the role play activity that was previously lacking. In addition, the two required coaching sessions resulted in a role play activity that was both taken seriously and completed with careful attention to each scenario, character development, and interpersonal communication concepts. The communication instructor's expertise in interpersonal communication and the rapport developed with the students through working with them in the classroom for two months, contributed to a thoughtful discussion of team communication. Finally, the engineering professor contextualized the activity by illustrating how the concepts learned would be beneficial in the workplace. The result was a classroom experience that the students will remember and development of knowledge about teaming and communication that can be incorporated in other engineering courses, as well as after graduation.

Recommendations and Conclusions

Despite our success with this exercise, we offer recommendations for future iterations of this instruction and other similar approaches. First, we recommend that this activity be expanded to include more scenarios. We completed only two role plays due to the time constraints we faced in the classroom, and the number of students who volunteered to be a part of the activity. Instead, we recommend completing four role plays and having short, more focused debriefing sessions. This will not only expose students to several different team scenarios, it will also keep students interested and participating in the discussions following the activity. Second, to encourage better discussion from the students, we recommend distributing a handout with guiding questions to be completed during each role play. This will ensure that each student has something to contribute and will also keep them focused as we progress through each scenario. Finally, we recommend that this activity be expanded from a voluntary exercise for only a few students to a required exercise for all students. Despite the fact that students viewed the activity as applicable and useful regardless of whether they participated in the role play or were observers, we believe that the students who benefited the most were those who attended the coaching sessions. As a result, we plan to require all students to participate in a teamwork role play coaching session. We are fortunate because this particular course is a lecture/lab course, thus allowing us to complete the coaching sessions during students' regularly scheduled weekly lab time. Teams will then be randomly selected to perform their role plays for each other in the lecture section, followed by the debriefing session.

In short, our goal was to provide a model for teaching teamwork principles and the associated communicative competencies necessary for a successful, productive team experience, for the benefit of our students. For if they are truly *taught* the requisite teamwork skills necessary for effective team functioning, they will likely have more positive team experiences, and thus be better prepared for this aspect of their professional lives. We are confident that this multidisciplinary, interactive activity is a step in the right direction.

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Appendix A
Team Roles and Norms Role Play Scenario

Team roles and norms: Working through confusion

Scenario

This team is part of the introductory class in mechanical engineering. We are about 1/3 into the semester. The assignment for the class is to design a vehicle that can carry an egg safely through an obstacle course. They have to compete with all the other class teams. If they win they don't have to take the final exam. This team is convening for their regularly scheduled weekly team meeting and the topic for discussion is "evaluating and choosing alternatives." Student teams have progressed through identifying strategies, functions, and specifications, to identifying sub-problems, parameters, functions, and target specifications, to idea generation. The next step in the design process is making a design decision by choosing from among the available alternatives. That is the purpose of this team meeting. The students, Rachel, Jared, Ben, and Sam are hoping to choose the best design to help them win the competition and thus, not have to take the final.

Jared is the official team leader for this phase of the project. When the team developed their working agreement, they decided that leadership would rotate from team member to team member. In addition, they decided that the leader would be responsible for having an agenda to guide interactions during the meeting, and would keep the team on task and encourage participation from every member. As a result, Jared's agenda items include discussing the PCC chart, objective tree, and decision matrix to help the team systematically choose the best design.

The following information is the basis for the dialogue that ensues.

Jared
Jared is the official team leader. He has a passive communication style, but is very thoughtful in his contributions to the team. He takes the working agreement very seriously and is committed to having all members of the team participate equally.

Rachel
Rachel was the official team leader for the previous phase of this project. She is domineering and is often impatient with the design process. Her goal is to be extremely efficient and as a result, she often skips over agenda items to get her goals accomplished with minimal time and minimal team discussion.

Ben
Ben has not yet been a leader in this team, but is an active team member. He is even-tempered and encourages participation from everyone. Producing a quality vehicle is his top priority. He is extremely committed to the project and believes the best way to accomplish their goals is by relying on the expertise of all team members. Ben and Rachel are friends outside of class.

Sam
Sam's loyalties flip-flop. He will be an advocate for Jared, the self-proclaimed leader, one minute and a part of the coalition that sometimes develops between Ben and Jared. He wants to do a good job, but is basically a silent member who goes along with different people at different times.

Appendix B
Team Conflict Role Play Scenario

A team divided: Routine engineering conflict

Scenario
This team is part of the introductory class in mechanical engineering. We are about 2/3 into the semester. Last week the team gave a presentation and turned in a report on their design plan. The assignment for the class is to design a vehicle that can carry an egg safely through an obstacle course. They have to compete with all the other class teams. If they win they don't have to take the final exam. After they did their presentation last week, they were told they needed to rethink their device, especially the egg carrier. When they did their presentation they were cut off because it was too long but they were praised for bringing in a prototype of their proposed design. The team turned in a written report on time, but it had spelling errors and missed a key section on potential problems. It is one week later and the team is meeting for a review session

with the communication instructors. The students were instructed to arrive 10 minutes early to prepare for the review session.

Autumn, Claire, and Trine were largely responsible for the prototype. April and Kelly were mostly responsible for the presentation, delivery and slides. Trine did most of the work on the written report.

The following information is the basis for the dialogue that ensues.

April
Outgoing, interrupts, competitive, talks over other people in the team, confident, single, full-time student. Has issues with Andy, who leaves early and comes late and always uses family as an excuse. Is mad at Andy for failing to bring a printout of the presentation slides to the meeting. Worked with Kelly on preparing slides for team presentation. Dismisses Kelly's suggestion to add Clair's drawing to the slides. Was responsible for presenting a large part of the presentation. Feels good about the presentation.
Conflict style: Forceful

Kelly
Withdrawn, quiet. Goes along with what strong people in the team say. Worked with April on presentation, but had little influence on style/content. Was responsible for presenting a large part. Tried to include Clair's drawing, but April dismissed it because she did not see it as relevant. Feels bad about the presentation.
Conflict style: Withdrawal

Trine
Competitive, focused on the task, works hard, feels like no one else does anything. Really feels like engineering is what she wants to do. Works a lot with Clair and Autumn in the lab. Wrote a large portion of the written report. Feels like no one else is serious enough. Gets defensive when she is accused of not e-mailing out a summary of last week's meeting. Is frustrated with Andy for wanting to change the wheel design at this time. Feels it is important to focus on a better way to carry the egg, because it keeps breaking. Thinks the best solution would be to carve a space for the egg inside the device.
Conflict style: Confrontation

Clair
Creative, collaborative, team focused, tries to encourage all team members to participate, has some education in art. Always wants to think outside the box and make time for idea generation. Brings up the working agreement to figure out which person had what responsibilities with regards to meeting summaries etc. Reminds Trine that she should have sent out a summary after last week's meeting. Works a lot with Trine and Autumn in the lab. Spent a lot of time on developing a drawing for the oral presentation, which Kelly promised to include. Feels it is important to focus on a better way to carry the egg, because it having the egg higher up will give them more points. Thinks the best solution would be to carry the egg in a cage on the top of the vehicle.

Conflict style: Compromise

Autumn
Accommodating, keeps the peace and is supportive of everyone and everything, takes notes, presents ideas, but they are never heard. She often shifts the topic of conversation to something non-task related (i.e. asking Clair about art, asking April about shopping, asking Andy about his kids etc). She is not taken seriously by other members of the team. Works in the lab with Trine and Clair, but usually does what they tell her to do. Not sure if she wants to study mechanical engineering.
Conflict style: Smoothing

Andy
Is always late. Older (non-traditional student). Has some work experience in the engineering field that he feels set him above the other students. Does not think communication should be a part of the engineering education. Thinks family is much more important than school and thinks this is a valid reason for not showing up, not being on time, having to leave early, not having completed work, not responding to e-mails etc. Helps a little bit with everything when he is at meetings. Did not bring slides to review session, because he did not know/did not remember that this was assigned to him. Wants the team to move from a 4-wheel to a 3-wheel design.
Conflict style: Forceful

Appendix C
Role Play Survey

Mechanical Engineering Role Play Survey

Instructions: The Center for Engineering Leadership is evaluating the effectiveness of teamwork instruction in Mechanical Engineering. Please take a few minutes and complete this survey by responding completely to the following questions.

Part I: Evaluate today's teamwork activity by responding to the following questions.

What did you learn by watching the teamwork role plays?

What did you learn in the discussion following the role plays?

Rate the applicability of the material you learned to your work as part of a student team in this course.

Not at all Applicable				Very Applicable
1	2	3	4	5

Do you think you will utilize what you learned from the role play activity and discussion in the future? How?

Would you recommend similar activities for other Mechanical Engineering courses? Why or why not?

What other teamwork activities would you like to participate in?

Part II: Evaluate your overall experience with teamwork instruction in Mechanical Engineering.

Overall, rate your satisfaction with teamwork instruction in Mechanical Engineering.

Not at all Satisfied				Very Satisfied
1	2	3	4	5

What could be done to improve teamwork instruction in Mechanical Engineering?

Part III: Demographic Information – Please circle the appropriate response.

Sex**:**	Male	Female		
Age:	18-22	23-27	28-32	33 and over
Class Standing:	Freshman	Sophomore	Junior	Senior

Engineering Experience:

Employed as an engineer

Employed as a pre-professional engineer

Employed as a manager in a non-engineering field

Employed as an employee in a non-engineering field

Not employed/full-tine student

Other (please explain):

Thank you for taking the time to complete our survey. Feel free to add any additional comments here: