The Impact of Professional Communications Training on Teamwork and Leadership Skills for Engineering Capstone Teams

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Abstract: Experience has shown that one of the biggest challenges facing engineering capstone teams is team members learning to work together effectively. This is compounded when the team is comprised of students from multiple engineering disciplines.

Our engineering capstone curriculum has always included training on team dynamics and team conflict that has been taught by the capstone engineering professors. Three years ago, we decided to bring in outside experts to lecture on topics such as project management, ethics and standards to augment the training for our capstone students. The following year we decided to extend this concept and turned to experts trained in the field of business communications to better train students in how to effectively operate as a team.

This paper describes an ongoing pilot project to integrate professional training on team dynamics, team conflict and team leadership into our existing engineering capstone curriculum. Business Communications professors from the School of Management developed curriculum and presented to engineering students in the Biomedical and Mechanical Engineering departments. The initial single training session two years ago on all these topics has expanded into multiple training sessions – one on team charters and team dynamics, a second session on team conflict and resolution and a third on formal presentation training. A "Team Health Checklist" has been developed to quickly gather feedback from the team members on their impressions about how their team is functioning. The Team Health Checklist is completed by all students during the second training session, and the results are tabulated to provide an assessment of team progress. Finally, all of the project team leaders attend a fourth training session/roundtable on team leadership in small groups to discuss issues without the engineering professors present. The results and comments from the Team Health Checklist are discussed with the team leaders, and coaching is provided to help them improve as leaders.

We will also discuss the results of the survey we have administered which has helped us determine the effectiveness of this professional training program. The survey focuses on each team member's impression of the change in attitudes, communications and abilities of the team before and after the training. Team leaders complete an additional section of the survey focused on their impressions of how and if the training has helped them perform better as the leader of the team.

Introduction

Engineering is a field where technical abilities and experience are highly valued and contribute to an engineer's success. Engineering schools strive to prepare their students in both of these

areas through rigorous education and practice. Technical abilities are taught and practiced throughout the curriculum, and capstone is where students are given the opportunity to gain valuable "real world" experience on an open-ended, team-based engineering project.

The other component to success in engineering, particularly for new college graduates, is the ability to master professional or soft skills such as communication, project management and interpersonal skills. Companies routinely look for and prize individuals that exhibit these professional skills [1-4].

Teamwork is an important skill needed for success in engineering capstone courses. A recent nationwide survey of engineering capstone program programs revealed that only slightly more than half of the programs covered teamwork in the lecture part of the course [5]. In most cases, teamwork was assumed to be a skill embedded in the project process. Oakley, et al. [6] present a framework for forming and managing teams while pointing out that "Students are not born knowing how to work in teams." They advocate an approach involving some brief initial teamwork training followed by more individualized mentoring with teams that are experiencing problems. Others have specifically addressed the topic of teamwork training in engineering capstone courses [7,8]. Gilbuena, et al. [9] have examined the more general issue of professional skills in capstone courses.

When it comes to capstone, we have seen that one of the biggest challenges faced by teams is learning to work together and communicate effectively. These challenges are compounded when a team is comprised of students from multiple engineering disciplines. As a general rule, the students arrive at the beginning of capstone with the majority of the technical skills they need to be successful, but few, unless they have outside work experience or have completed an internship, have the professional skills needed to navigate the dynamics of a new team working on a large, open-ended project. We therefore consciously decided to focus our instruction on these missing professional skills. Any additional technical skills that a team or an individual student needed would be acquired on their own.

This paper describes the ongoing pilot program in the Biomedical and Mechanical Engineering departments to integrate professional training on soft skills into our existing engineering capstone curriculum. In addition to instruction by the capstone professors, for the past three years we have brought in outside experts to lecture on topics such as project management, ethics, standards and innovation to improve the overall instruction plan and to provide our students with additional points of view on these topics.

We also recognized that teamwork, team dynamics, team leadership and conflict resolution were critical skills that our students needed to develop in order to be successful in capstone and beyond. So we contacted the Business Communications department in our School of

Management and have partnered with two professors and they developed a curriculum to provide additional focused instruction in these areas. What started as a single training session two years ago has expanded into multiple training sessions on team charters, team dynamics, team conflict and resolution, team leader training and formal presentation training.

We surveyed the students halfway through the project cycle to evaluate the professional skills training sessions and to gather feedback on their team's collaboration, progress, communication and leadership to help determine the impact of the training. The results of this survey are discussed and we draw conclusions based on the data.

Background and Motivation

At UT Dallas, two-semester engineering capstone projects are completed by all students in Biomedical (BMEN), Electrical (EE) and Mechanical Engineering (MECH). The Mechanical and Biomedical Engineering departments are relatively new additions to the UT Dallas engineering school, with capstone first offered in the Fall 2012 and Fall 2014 semesters respectively. The first version of the current capstone curriculum was developed in Mechanical Engineering in 2012, adopted by Electrical Engineering in 2013 and then adopted by Biomedical Engineering in 2014. The three departments have continued to evolve the curriculum into the current version that is being used.

At the beginning of the semester, the available projects are presented to each department's capstone class. The capstone professors predetermine which engineering disciplines will be included on each project, and the students are then allowed to bid on the projects they are interested in. The capstone professors then form the individual teams and they begin working on their designated project.

As work progressed on the projects, we noticed that teams bond differently, and that work advanced at different rates, typically based on the level of team cohesion. As mentioned earlier, this bonding process seemed to move slower when there are students from multiple engineering disciplines on a team. We also noticed that the teams that bonded at a slower rate, whether single discipline or multidisciplinary, tended to produce inferior results to teams that bonded more quickly. In other words, the initial problems with developing as a team tended to continue throughout the entire project cycle.

We attributed this to two factors – less familiarity with students from other departments and differences in curriculum/processes taught in each department prior to capstone. To address these two factors we implemented several changes to the capstone curriculum.

First off, based on the high number of multidisciplinary teams comprised of Biomedical and Mechanical Engineering students, the two departments made the decision to merge their capstone classes together. This allows the entire team to be together for all training activities to accelerate team cohesion. Additionally, any Electrical Engineering students on multidisciplinary teams are required to attend all training sessions with their teammates.

Our engineering program utilizes team-based project learning in several course beginning freshman year. In these courses, the engineering professors introduce the concepts of teamwork, collaboration and conflict resolution. These concepts are reinforced at several points throughout engineering students' academic career in other lab courses and even in some lecture courses, but they are not the focus of those courses.

So for capstone we decided to focus on professional skills almost exclusively during lecture, and began bringing in outside experts to lecture on different topics related to professional skills. While we brought in experts on project management, ethics, standards and innovation, we realized that the biggest areas of emphasis needed to be communication, team dynamics and team cohesion.

A chance reading of an article in 2014 about several professors in the Business Communications (BCOM) department and their work with teams led the capstone professors (Hart, Pacheco and Polk) to contact the Business Communications professors (Sluder and Smallwood) to discuss the capstone project course and ways that they might be able to help us improve the way teams were working together. After several brainstorming and needs assessment meetings, we launched what would become an ongoing, year-round partnership to help improve engineering students' soft skills. What began as a single guest lecture covering team charters, team dynamics and team conflict and resolution has now grown into a series of three lectures targeting all capstone students and two additional sessions with just the team leaders to help improve their leadership skills. As of Fall 2016, Sluder and Smallwood have provided communication, teamwork, team building and conflict management training to 450 engineering students.

Others have recognized the need for training in teamwork and related skills in capstone courses. Sarang-Sieminski, et al. [7] presents an approach in which students learn and practice these skills in multiple courses prior to capstone. The authors do not mention providing any further formal training in the capstone course, but they do support team health with activities such as peer reviews and periodic reflections on team dynamics. Interestingly, Giurintano, et al. [8], found a need to focus on teamwork and leadership coaching after observing a lack of effective teamwork among interdisciplinary teams. They adopted an approach similar to that discussed here with several capstone lectures devoted to teamwork and related topics. They also provided specialized training to interdisciplinary teams. However, an important difference from our approach is that their capstone instructors developed and provided the training. The authors

reported that 70% of students surveyed felt that the material was valuable and only 6% said that it had no value to them. This outcome supports the validity of our approach.

Methodology

Our university is regularly recognized as one of the country's most diverse universities [10] and the engineering students' teams demonstrate this diversity. Students range in age from under 21 to more than 30; include both international and domestic students; and while predominantly male, also include females. While such diversity can be a great strength for teams, it can also pose communication challenges [11].

To facilitate the training on team dynamics, teamwork and communication, The BCOM professors lead three very focused training sessions for the capstone students, and two additional sessions for just the team leaders. The three full course sessions cover team dynamics and teamwork, team conflict and resolution, and formal presentation training. The team leader-only sessions are small discussion format roundtables to provide more focused and individual training to the team leaders. More details on the sessions are given below.

We conduct an initial communications assessment each semester to ask students how important they think the ability to communicate will be in their future engineering profession. In the Fall 2016 semester, 95 of 136 students, or 69.85 percent, said communications ability would be "super important" or "essential", while 39, or 28.68 percent, ranked it as "very important" to their future careers. Two students said their communications ability would be "moderately important". No students said it would be only slightly important or not important to their future careers. Students also were asked how much they personally valued "hard skills," such as design and engineering, and "soft skills," such as communication and teamwork. The majority, 60.29 percent or 82 of 136 students, said they valued hard and soft skills equally. Twenty-four students, or 17.65 percent, said that hard skills were more important than soft skills. Thirty students, or 22.06 percent, placed more value on soft skills than hard skills.

To develop students' communication skills, we use a number of practical techniques to make the topic of communication tangible rather than theoretical. We present skits of common communication problems such as how to confront a team member who regularly arrives late to meetings or who misses deadlines. We talk about good and bad solutions, and ask the students to reflect on their own experiences on the engineering teams and teams in other classes. We also ask students to assess and rank at various stages of the training program:

- What they think of their individual communication skills overall, which we define as the ability to write, speak and present.

- What's most important for their team to succeed on the project: overall communication skills, overall engineering capabilities, or the ability to meet deadlines.
- What's most important to them as a team member: succeeding, having open communication, or getting along with their team members.
- What role they expect of their team leader and fellow members.

The student responses allow us to assess the students' communication strengths and weaknesses, with the goal being to enhance their abilities to communicate effectively with a wide range of audiences, such as their sponsors, professors, faculty advisors and peers. Especially given the diversity of the engineering teams, we orient the training to avoid the "group think" that many diverse teams experience. Goby [11] found that people in culturally diverse settings sometimes "hyper-conform" because of their increased sensitivity to cultural differences and their desire to avoid conflict. Throughout the program, we encourage students to have open discussions with their teams and we stress that no two teams will be alike.

Teamwork

As we know, these engineering capstone classes are all about teamwork. Before the students even are assigned the project, they are put into teams. They can pick their own team or the team can be randomly generated. Once the team is formed, their next step is to choose a team leader. And, from this very beginning, they are a team for the next two semesters as they work through to the completion of their capstone project.

As professors of Business Communication we utilize Tuckman's four phases to the life cycle of a team (forming, storming, norming, and performing) when teaching teamwork in our courses. As Guffey [12] asserts in *Essentials of Business Communication*, "Regardless of their specific purpose, teams normally go through predictable phases as they develop." Research also indicates that these phases are "applicable to the capstone team process" as discussed in Hoffman's [13] *The Engineering Capstone Course: Fundamentals for Students and Instructors.* Consequently, part of the purpose of our collaboration with these capstone classes is to help the teams be more successful at navigating through these phases. In their 2011 article "Teaching Teamwork in Engineering and Computer Science," Lingard and Barkataki acknowledge that most of these capstone type programs "give students many opportunities to participate in team projects, but they do little to help students develop or improve specific teamwork skills." [14] They further elaborate that this is because 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."

In the forming stage, the teams are given an assignment to develop a team charter that defines the team's structure, goals, and capabilities. In addition to arriving at these definitions, the

assignment is also postured in such a way so as to give the team the opportunity to learn more about their individual team members' strengths, backgrounds, and expectations. The specific requirements for this assignment are for the team to do the following:

- Choose a team name and logo.
- Provide their contact information.
- Establish a set of team goals.
- Review the capabilities of their team.
- Describe their approach to the management of their team
- Establish a set of rules for the operation of their team.
- Create a document to introduce themselves to their corporate sponsor and faculty advisor.

But true to what Lingard and Barkataki assert, even when given this team activity with clearly defined parameters the students were just not very effective in completing the assignment. In a survey that Lingard and Barkataki did among students participating in team projects they found evidence that "suggests that students are challenged when it comes to collaboration skills." In response, Lingard and Barkataki decided to take the approach "to encourage or, more precisely, demand greater student collaboration."

Consequently, the approach we take is for the engineering professors to give out the team charter assignment on the second day of class. The teams are given two weeks to complete the assignment. After the first week, we hold a workshop in their class to further elaborate on each of the bullet point items on the charter and to facilitate team discussion on each item. While the teams come to class thinking that they have worked as a team and just about completed their charter, our facilitation really does change the whole dynamic. Facilitation is about movement [15]. As facilitators, we can help guide the individuals in the group toward a group consensus while paying particular attention to the fact that each individual has something to contribute. For each bullet point item, we create worksheets and activities geared toward making the students think on their own but work (and talk) as a team. We "demand greater student collaboration". At the beginning it is somewhat difficult to get these students to speak up but by the end of the workshop, there is an obvious excitement in the room for building strong, focused teams. In regard to the forming stage, we think the students met the goals of this phase: to get to know each other, to build trust, and to form a collaborative culture [12].

Conflict Management

Because conflict is an unavoidable part of teamwork and because both professionals and students lack training in this area, conflict management training is an essential part of our program. First, we preface the session by explaining to students that we are discussing normal, not abusive, conflict. We stress the difference between constructive and destructive conflict and present

scenarios asking students to identify each type of conflict. The training stresses that constructive conflict focuses on disagreement over substantive issues and is not personalized. It strengthens team cohesion; helps people think differently; and increases individual involvement [16]. However, emotion-laden, destructive conflict zeroes in on personality differences, and polarizes and distracts teams. Next, we examine what causes conflict, including nine factors such as time pressures, unclear task assignments, competition, and lack of understanding. When asked which of these factors could impact their teams, students usually laugh and reply "all". The session reviews ineffective ways to deal with conflict, such as avoidance, aggression, blame or denial [17]. We discuss cultural differences in expressing and managing conflict, which encourages international students to describe how conflict is handled in their cultures. The session then examines effective conflict management styles, which combine cooperativeness and assertiveness to facilitate collaboration. Finally, we explore how to de-escalate and resolve conflict positively and to create a "win-win" situation for all parties, as DeChurch and Marks explored [17]. For example, we discuss how to deal with a team member who is regularly late to meetings factually and without anger so that the individual is motivated to change his or her behavior rather than to get defensive when confronted.

Initially, even raising the topic of conflict makes students uncomfortable. Despite students' discomfort, we stress that conflict is normal, can usually be managed, can motivate change and can strengthen relationships. Since the program was launched, we have added skits to the conflict management presentation. Currently, we include three skits (acted out by us or us with a student) of typical conflicts encountered in groups, such as a member who is always late, a member who blames someone else for mistakes, and an individual who is rude and insulting. While the skits entertain the students and break some of the tension, they also help students recognize conflicts occurring within their own groups. After each skit, we lead a classroom discussion of how to best deal with the situation and which actions the team leader and team members should take. We have found that, after the skits, students are much more expressive about their prior experiences with group conflict and about their current team dynamics.

Leadership Coaching

As part of our workshop, we give the students a Team Health Checklist which is a form designed to help teams review their effectiveness. Each team member is asked to score their personal assessment of the way the team is working right then and there. They are asked to give a rating between 0 and 5 with 5 being Strongly Agree and 0 being Strongly Disagree. The categories for assessment are (1) Purpose/Direction, (2) Team Leadership, (3) Processes, (4) Understanding Differences, (5) Communication and (6) Relationships.

Under Team Leadership, each member rates his/her team leader on the following:

- Balances appropriate direction with support and openness
- Discusses key issues with the team
- Delegates responsibility and leadership to individuals in their area of expertise

During the workshop we give the students time to fill out the form and then we open it up for class discussion. While the students seem free to discuss how their team is doing in most of the areas, we have found it more difficult for them to openly discuss how they feel the leadership of the team is going. Yet, as John C. Maxwell [18] asserts in *The 21 Indispensable Qualities of a Leader*, "Everything rises and falls on leadership." Certainly the success of the team project rests on the shoulders of the team lead but also being a successful team lead could be the difference between getting a good job offer and not getting one. In the article, "How Important is Your Senior Engineering Project," featured in the 2015 Engineer Guide to Getting an Engineering Job [19] one of the points made as to what employers are looking for that a recent graduate can prove from their capstone project is if they took a leadership role in the project because it "shows an employer that [they're] able to handle responsibility and management."

So, our goal is to provide a coaching session with us for the team leads away from the teams (and their advisors, sponsors and capstone professors) and in a separate place and time. Taking into account several basic steps put forth in "The Subtle Art of Coaching" [20] we take the following approach: (1) Keep the conversation casual, (2) Listen actively, (3) Ask questions to clarify the situation, (4) Offer support as needed, (5) Help the lead identify possible courses of action and (6) Motivate the team lead to go back to their teams and take action.

To start the session, we give the team leads a Leadership Self-Test which has been developed by Dr. A. J. Schuler, who is considered an authority on leadership issues. The test poses 15 True/False questions which are used to stimulate self- reflection on whether you see yourself as a leader or a manager. After the leads have finished the test, we give them Part II of this test which provides discussion on the premise that it's not really a matter of being one or the other but that most management positions require both strong management skills and strong leadership skills.

We then move into the next phase of this session by distributing to each team lead a report showing an average analysis of the scores given by their team members in each category of the Team Health Check. This information quickly lets each team lead know how they are doing in each one of the six categories. As coaches, we have already analyzed the information to determine which teams are doing the best and, taking a positive approach, we ask each of those teams leads to discuss why they think their team is doing so well in that particular area. We have found this approach to be very successful in generating quite a bit of discussion and the team

leads seem to leave the session having a better idea of what is working well for the teams and why.

We also conduct a second team leader training session approximately 5-6 weeks before the end of the projects to help prepare and support the team leaders for the final project push to completion. The format of this session will be similar to the first session, and will allow us to help the team leaders focus on areas important to project completion.

Survey

The voluntary survey distributed to the capstone students was broad in scope and was aimed at understanding several aspects of team dynamics, communication and leadership in engineering capstone projects (UT Dallas IRB Approval No. MR 17-041). The questions on the survey coincided with the areas of the training program. Survey questions were designed to assess the success of the training program, and were selected based on the Business Communications professors' communications knowledge and instructional experience in that area. The survey was divided into three sections with the first section completed by all students, the second section being completed only by non-team leaders, and the third section being completed only by the Engineering Team Leaders (ETLs).

For this paper, we focus on the analysis of a subset of questions related to how students felt their communication and leadership skills have changed during the first semester of the capstone course. While additional questions were asked during the survey, the results to follow will be limited to the questions listed below in Table 1.

Questions for all students surveyed

1. Compare your team's purpose and direction today with how it was at the inception of the capstone project. Is it: Better, The same, or Worse
2. A two-part question on team communication:
    a. How is the communication within your team now? (3-point response scale Great/OK/Poor)
    b. Is the communication within your team at present different than the communication at the inception of the capstone project? (3-point response scale Better/Same/Worse)
3. A two-part question on individual communication:
    a. How would you rank your own overall communication skills at this time, including the ability to write, speak and present clearly? (5-point response scale from Excellent to Terrible)
    b. Have your own overall communication skills, including the ability to write, speak and present clearly, changed to their present state from where your skills were at the inception of the capstone project? (3-point response scale Improved/About the same/Deteriorated)

Question for only non-team leaders
4. Compare your Engineering Team Leader now with how he or she was at the inception of your capstone project. Is the lead: (5-point response scale from Much better to Much worse)
Question for only Engineering Team Leaders
5. Compare yourself as Engineering Team Leader at the inception of this capstone project to how you are doing now. Are you: Leading more effectively, Leading about the same, or Leading not as well

Table 1: Survey questions related to changes in communication and leaders skills

Survey Results

Table 2 below shows the total enrollment for the course and the division among the three majors who were participating in this jointly taught course.

Major	Number students
Mechanical Engineering (MECH)	98
Biomedical Engineering (BMEN)	57
Electrical Engineering (EE)	4
Total Number students	**159**

Table 2: Total Enrollment of Capstone Course Surveyed

The 159 students are divided among 30 teams, each of which has one Engineering Team Leader. Of the 30 teams, 14 teams are joint MECH/BMEN teams, 2 are joint MECH/EE teams, 4 are BMEN only teams, and 10 are MECH only teams.

After a two-week survey period, 92 complete responses and 1 partial response were received. Table 3 below shows the breakdown of the responses received in terms of major and team type (i.e., single or multidisciplinary).

Major	Multi	Single	Total
MECH	26	29	55
BMEN	22	15	37
EE	1	0	1
Total	**49**	**44**	**93**

Table 3: Breakdown of survey responses received

Of the 93 total responses, 19 were Engineering Team Leads (ETLs) and 74 were not team leaders. Table 4 below shows the breakdown of the responses received from ETLs in terms of major and team type (i.e., single or multidisciplinary).

Major	Multi	Single	Total
MECH	4	6	10
BMEN	5	4	9
EE	0	0	0
Total	**9**	**10**	**19**

Table 4: Breakdown of survey responses received from ETLs

Below are the results of the survey to the questions in Table 1. In some cases, the data is presented in bar graphs that show the percentage of students for each team type (i.e., single vs. multidisciplinary), and in other cases where the results between single and multidisciplinary were not significantly different, the data is presented in a single table.

Figure 1 below shows the results of survey question #1 related to how the respondent feels his or her team's purpose and direction has changed since the inception of the project. Of the 93 respondents, 68 of them felt that their purpose and direction has gotten better, 22 felt it was the same, and 3 students felt it has gotten worse.

Overall the majority of students agreed that purpose and direction have improved, however the multidisciplinary teams still lag behind the single discipline teams in satisfaction. Statistically speaking this was the only question that showed marginal independence based on team type, with a p-value of .075. Statistical details for all questions are shown in the next section below.

We attribute this to the typically broader scope of multidisciplinary projects, and that students have to learn to work with students outside of their major which slows the rate of team cohesion relative to single discipline teams.

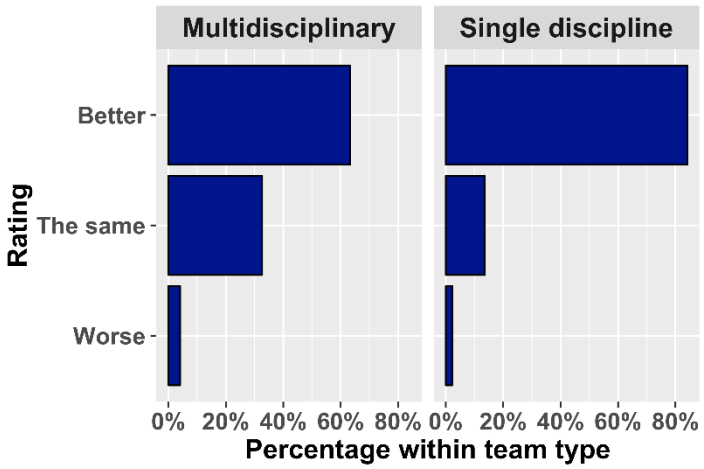

Figure 1: Results of Survey Question #1 on Team Purpose and Direction

Table 5 below shows the results of survey question #2 related to how the respondent feels his or her team's communication has changed since the inception of the project. Of the 93 respondents, 46 of them felt it has gotten better, 45 felt it was the same, and 2 students felt it has gotten worse. Overall, 76% surveyed believe that their team communication was either good to start with or has improved.

We attribute the fact that 45 students felt their communication was the same partly to the timing of the survey. The survey was done when teams were still in the honeymoon phase of team development. An additional factor contributing to 45 students saying that their communication was unchanged is how highly students, in general, assess their communication skills. In a 2015 survey comparing how students assess their skills to how employers hiring new graduates assess their skills, 64 percent of students said they were good at working on teams, while only 27 percent of employers said students were skilled in that area [21]. Another 20% felt that their team communication was OK to start with and has stayed the same, while the remaining 4% believe that communication on their team was poor to begin with and has not improved or has worsened.

Change From Inception	**Team Communication Now**		
	Poor	**OK**	**Great**
Worse	1	1	0
Same	1	19	25
Better	0	13	33

Table 5: Results of Survey Question #2 on Team Communication

Table 6 below shows the results of survey question #3 related to the change in individual communication skills from the inception of the project to the time of the survey. Overall, 96%

surveyed believe that their communication skills were either good to start with or had improved. Another 3% felt that their communication skills were OK to start with and has stayed the same, while the remaining 1% believe that their communication skills were poor to begin with and have not improved.

The table also shows that 57% believe their communication skills have improved since the inception of the project.

	Poor	Average	Good
Improved	0	4	48
Same	1	3	36
Deteriorated	0	0	0

Table 6: Results of Survey Question #3 on Individual Communication

Figure 2 below shows the results of survey question #4 related to how the respondents who were not team leaders felt about how his or her Engineering Team Leader's (ETL) ability to lead has changed. Of the 74 non-ETL respondents, 16 felt they were leading much better, 27 felt they were leading somewhat better, 27 felt they were leading about the same, 4 felt they were leading somewhat worse, and 0 students felt they were leading much worse.

Overall 58% believe their ETL is leading better. We attribute this to two factors – leader training and experience.

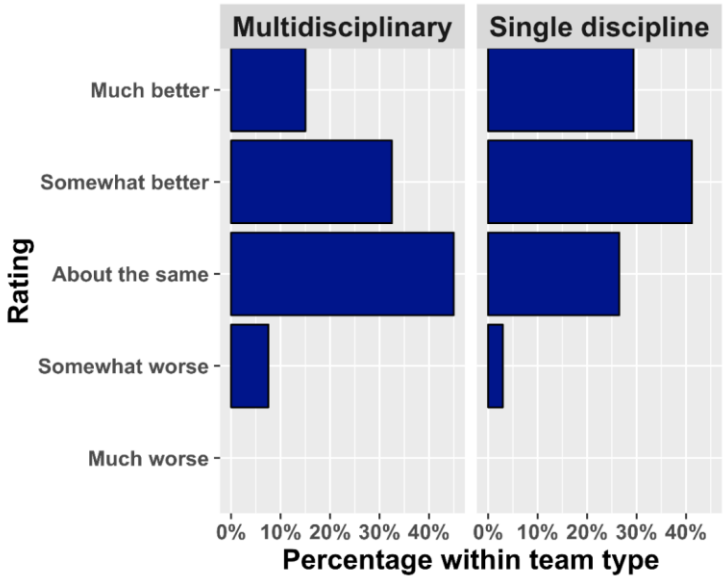

Figure 2: Results of Survey Question #4: How the team views their ETL's ability to lead

Figure 3 below shows the results of survey question #5 related to how the respondent as an Engineering Team Leader (ETL) feels his or her own ability to lead has changed since the inception of the capstone course. Of the 19 ETL respondents, 14 of them felt they were leading more effectively, 5 felt they were leading about as effectively as at the start of the project, and 0 ETLs felt they were leading less effectively. Again we can attribute these numbers to the same two factors – leader training and experience.

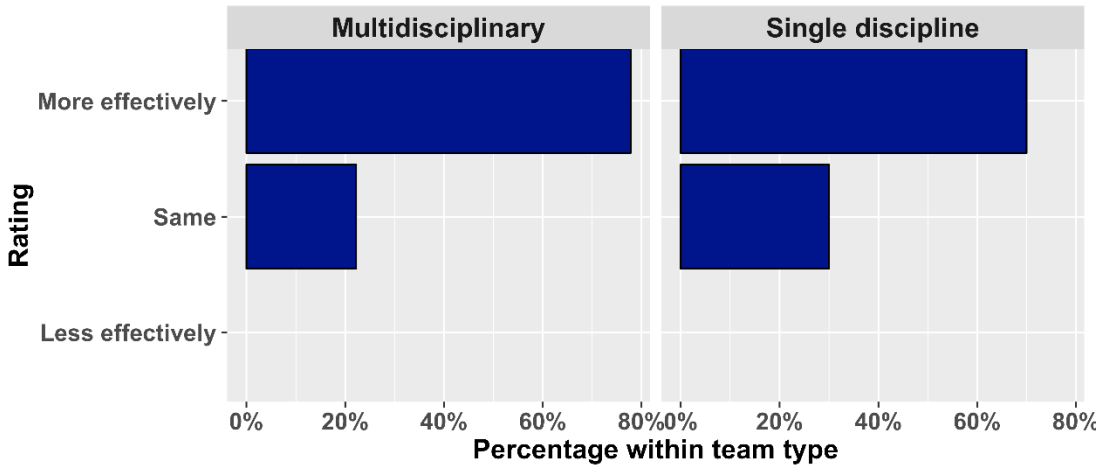

Figure 3: Results of Survey Question #5: How the ETL views his/her own ability to lead

Based on previous experience with teaching capstone courses that involved multidisciplinary teams, we were interested to see if there were any differences in how students on multidisciplinary teams versus single discipline teams responded to the questionnaire. Anecdotally, we noted in previous years that there were often significant differences in performance, communication style, and leadership ability. Because we do not have survey data for students before we instituted the professional communication and leadership training and other changes discussed in previous sections, we are not able to directly measure the impact of the training and changes. Nevertheless, the data obtained provides insight into the functioning of the current capstone teams.

To test the whether the results of the survey question results are independent of the team type (i.e., multi vs. single) the student is on, we used Pearson's Chi-Squared test. The results for the seven questions of interest are shown in Table 7.

Question Number	p-value
1	0.0760
2a	0.9814
2b	0.7643
3a	0.1512
3b	> 0.999
4	0.2052
5	>0.999

Table 7: p-values for Pearson's Chi-Square test

As can be seen, for all but the first question, the Chi-Squared test indicated that there were no significant differences between the multidisciplinary and single-disciplinary team respondents. While we cannot draw definite conclusions about the impact of the training, we can conclude that single and multidisciplinary teams are functioning equally well in the current capstone class.

In future studies we plan to modify the survey to allow us to quantitatively assess the impact of our training.

Conclusion

The need for engineering students to learn and master professional skills has been documented by multiple surveys. Focusing capstone classroom instruction on these soft skills makes sense, as students typically arrive at capstone with a majority of the technical skills they need to begin successful careers, but with very little exposure to the teamwork, collaboration and communication skills that hiring companies demand. Typically the students are formed in teams and asked to learn these skills "on the job" rather than looking for and utilizing professional trainers to fully prepare them to enter the workforce.

Seeing this need led us to add lectures on various professional skills into the capstone curriculum by inviting expert guest speakers on these topics. The next step forward was the partnership with the two professors from the Business Communications department and the development of the pilot program described in this paper. By providing focused training on critical soft skills that engineers need, we are better preparing our engineering students to enter the professional working world after graduation.

Based on the results received to date, our perception is that our pilot program is on the right track and that the changes we have made and those we continue to implement are making positive improvements on our capstone engineering teams. We see marked improvement in the rate of team cohesion, particularly on our multidisciplinary teams. This is translating into improved results delivered by the teams at the conclusion of capstone. We definitely plan to continue the pilot program.

We also acknowledge that our survey needs updating to allow us to better quantify the factors behind the improvements we are seeing. Future work will include improving the survey to allow better quantification of the impact of the training versus improvements seen based on experience gained as students go through the capstone process.

In addition to updating the survey, we are also considering enhancing our study by incorporating project success metrics to determine whether there is a correlation between the student opinions given in the surveys versus actual outcomes. We are also exploring potential collaborations with other engineering departments at UT Dallas that do not currently use the Business Communications department developed curriculum. Because those other engineering departments use the same capstone project model as well as many of the same resources, they would serve as a good control to better understand the impact of the Business Communications training.

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