120th ASEE Annual Conference & Exposition
FRANKLY, WE DO GIVE A D*MN
June 23-26, 2013

Paper ID #7069

Teamwork in First-Year Engineering Projects Courses: Does Training Students in Team Dynamics Improve Course Outcomes and Student Experiences?

Dr. Malinda S Zarske, University of Colorado, Boulder

Malinda S. Zarske is the director of K-12 Engineering Education at the University of Colorado Boulder's College of Engineering and Applied Science. A former high school and middle school science and math teacher, she has advanced degrees in teaching secondary science from the Johns Hopkins University and in civil engineering from CU-Boulder. She is also a First-Year Engineering Projects Instructor, Faculty Advisor for SWE, and on the development team for the TeachEngineering digital library. Her primary research interests are on student identity, recruitment, and retention in K-12 and undergraduate engineering.

Ms. Janet L Yowell, University of Colorado Boulder

Janet serves as the Associate Director of K-12 Engineering Education for the College of Engineering and Applied Science at the University of Colorado Boulder. Involved since 2000, she collaborates on the College's ambitious K-12 engineering initiatives, including their capacity-building and school partnership programs. She coordinates the Integrated Teaching and Learning Program's NSF-funded TEAMS Program (Tomorrow's Engineers… creAte. iMagine. Succeed.) which engages more than 2,200 K-12 students in engineering throughout the academic year and summer months. She is also a contributing curriculum writer and editor for the TeachEngineering digital library, also an NSF-funded project. Janet holds a BA in Communication from CU-Boulder and is currently pursuing a master's degree in Information and Learning Technology at CU-Denver.

Ms. Samantha Maierhofer, University of Colorado, Boulder

Samantha Maierhofer is a Discovery Learning Apprentice at CU's College of Engineering and Applied Science. She is currently a sophomore studying Mechanical Engineering at CU. Her research interest is in the area of team dynamics on the engineering undergraduate experience. Her current duties include analyzing data and leading focus groups.

Prof. Derek T Reamon, University of Colorado, Boulder

Teamwork in First-Year Engineering Projects Courses: Does Training Students in Team Dynamics Improve Course Outcomes and Student Experiences?

Introduction

Collaboration and communication are two critical 21st century skills necessary to build a global and innovative national workforce—both of which are found in effective teamwork. The value of teamwork skills has been previously addressed in the research on first-year engineering programs. Unfortunately, most of the research has been done with relatively restricted populations over a single engineering discipline and with a focus on the methods of team formation and skills acquisition in teams.

For example, various conference papers written on engineering team formation techniques indicate that many instructors use a previously-developed cognitive styles tool to form teams in their courses, such as Myers-Briggs Type Indicator (MBTI), Six Thinking Hats, or a combination of others. The MBTI tool gives the student an indicator of their personality, while the modified Six Hats tool offers a specific communication style for the students. Multiple sources believe that for best results, a team should be formed by using both MBTI and Six Hats surveys to diversify team personalities.

Interestingly, many of the papers do not report the amount of training, if any, in team dynamics that is offered to the students throughout their team experience. The literature suggests that teaching students *how to work in teams* rather than trying to form perfect teams can provide more lasting benefits to students—preparing them for the real world where employers might not create perfect teams. Reasonable expected outcomes of effective teamwork training in first-year engineering undergraduate courses might include the practice of team conflict resolution in multiple settings, lasting relationships with other students, and increased communication skills with diverse individuals.

This research paper focuses on the analysis of multiple semesters of a multi-disciplinary, first-year engineering projects course (FYEP) in the College of Engineering and Applied Science at the University of Colorado Boulder that engages ~44% of the college's first-year students each year and is based on teamwork and product design. Data from this course has been collected for the past few years on team formation strategies, team size and demographics, amount of instruction in team dynamics, and individual confidence in technical and professional skills with the intent to inform course evolution. This research aims at discovering if there is value in training students on how teams work and how individuals may effectively work in teams. Using multiple methods informed by current education research, we quantitatively and qualitatively compare whether or not students were given any type of team dynamics and formation instruction to other factors, including final attitudes.

Our initial results indicate that there is no difference in self-reported skills acquisition by students with differing amounts of team dynamics training. Our final analysis also considers satisfaction of team performance as revealed in small focus groups. Finally, suggestions are made on the amount of class time to spend teaching students how to effectively work in teams.

Background

There is no question that teamwork has become an integral component in engineering education. Senior capstone courses and first-year engineering design courses are becoming ubiquitous within an undergraduate engineering education. It has been suggested that attention be paid to the formation of teams and that training in how to work as a team occurs early and often in engineering education.[1] Effective teams can provide many benefits to students, including an increase in knowledge and skills, such as communication, from working with people unlike themselves. Furthermore, such skills undoubtedly transition into myriad facets of life after college—rendering the skills an invaluable asset for engineering students.

Formation of Teams and Team Dynamics in Engineering Education

Teams and teamwork describes a group of individuals that work together toward a common goal;[2] team dynamics is specifically about the interactions between members of a group and how these interactions affect the productivity of the team.[3] Team dynamics are influenced by personalities of team members and how the team operates together.[3] In colleges of engineering, an ability to work in multidisciplinary teams has become an important learning objective, as evidenced by required student outcomes for accreditation.[4]

Our initial literature search revealed articles written about first-year engineering courses in which teamwork was a primary component of the course, and further offered information on the different methods around how these teams were formed. We found a variety of techniques used to form teams, including teams being 50% picked by students and 50% being picked by instructors, along with groupings according to the Six Hats and MBTI personality tests, cognitive styles, class standing, teamwork training, and diversifying attributes of team members.[1, 5,6,7,8,9,10] Other course instructors split students up using other factors, such as previous teamwork experience in engineering, and in some cases, random assignment. The literature search results did not favor one method over another; most of the results were more opinion then actual data.

Bacon, Stewart and Silver also researched the method of administering teams, specifically the teacher control that may affect team formation.[11] They found that self-selected groups were often comprised of people who were more likely to want to work with others whom they have worked with previously—due, in part, to the fact that social norms have already been established and the degree to which trust and comfort with teammates has surfaced. While self-selected groups foster productivity, they also have some drawbacks—lack of diversity and absence of critical skills required to carry out tasks, among others. Given these obstacles, the tradeoff is still viable for teams that have a brief life, especially if the need for uniqueness in skills is minimal. Through their research, Bacon et al. discussed the five stages of development (forming, storming, norming, performing and adjourning) for teams that have longevity and their impact on team experiences.[11] Among other constructs, the authors looked at the value that grades, peer evaluation, team size, team instructions and team training have on teams. The authors offered six recommendations for team formation in an educational setting. Their overall conclusion was that people learn more when they have good teamwork experiences.

Another interesting article by Feland stated that the subject of teamwork should be focused within teams, rather than the creation of “perfect teams.” [9] The reasoning behind this theory is that once students graduate and are asked to work in a team in a corporate setting, they will quickly realize that there is no such thing as a "perfect team." Companies usually group people based on the technical background needed for the job, not based on personality types that work well together; they often times do not have the time or options available to put together such a "perfect team." Thus, students must know how to work well with anyone.

Based on Feland's research on teaching students *how* to perform in teams rather than trying to create the perfect team, we conducted further research on how to *teach* teamwork and team dynamics.[9] One resource for assessing teamwork is the CATME (Comprehensive Assessment for Team-Member Effectiveness) system, which can be used to form teams by user input variables.[12] The CATME system also provides feedback to team members on their individual contributions to the team based on self- and peer-evaluations. This teaches students about effective practices for working in teams. Another research paper discusses how to use targeted exercises during class, with subsequent follow-ups to help students understand team dynamics and build teamwork.[13]

How much impact does learning about the five stages of development — forming, storming, norming, performing and adjourning — have on student experiences? The following research focuses on teaching students about team dynamics, specifically how much targeted training on how to work together in successful teams affects student skills acquisition and team performance.

Research Hypothesis

The overarching goal of this research was to analyze team dynamics and performance within several semesters of a first-year engineering design experience. During our literature review, we discovered previous research that suggests that it is actually better to teach students the skills needed to figure out *how* to work well in teams rather than to try to create the "perfect team." [6] Based on this idea, we refocused our research on *how much* training students receive on teamwork and team dynamics rather than specifically on *how teams were picked* and how this affected the performance of the students on the teams.

Specifically, five semesters of CU-Boulder's College of Engineering and Applied Science's (CEAS) first-year engineering projects class were analyzed. We investigated if the amount of intentional training in team dynamics impacts students' self-perceived technical and professional skills, and long-term perception of teamwork success. We asked the following questions: *When compared to receiving no training in team dynamics, do students who are trained to work in teams perceive increased gains in technical and professional skills for a sample of engineering undergraduate students enrolled in a first-year engineering projects course? Are these outcomes impacted by gender, ethnicity, or first-generation college bound student status?*

Methods

Setting for Analysis

The analysis for this research takes place in CU-Boulder's CEAS first-year engineering projects class (FYEP). This class, described through previous research, brings students from different disciplines, ethnicities, genders, and backgrounds together through a semester-long, team-based design project.[14] The nature of the projects are chosen by individual professors, and topics range from assistive technology projects with actual clients and Rube Goldberg contraptions to water filtration systems for developing countries, among others. Students spend the semester going through the design process and learning how to work together and complete the necessary steps to produce a tangible, well-thought out final project. The entire semester's work culminates with an Engineering Design Expo at the end of the semester. During the Expo, student team projects are evaluated by judges who are practicing engineers as well as showcased to the public.

Several engineering departments require the FYEP course for first-year students, including mechanical, civil, environmental, and aerospace engineering. Engineering students that are required to take the course do not necessarily enroll with a professor from their home department, resulting in a random assortment of student interests and skills in each section of the course. Students do not know section project topics at the time of registration, but can look up faculty interests and rankings prior to enrollment.

The FYEP course is a team-based projects course, and each student, therefore, is placed into a team of 4-5 students within each section to complete the semester-long project. Each section has a capped enrollment of 30 students, or approximately six teams per section. There is significant variability among team experiences, as individual professors choose their method of team formation and amount of team dynamics training.

Participants

The statistical analysis in this research contains survey data on approximately 462 FYEP engineering students enrolled in 20 sections of FYEP over five semesters (fall 2010 through fall 2012). Participants included 27% females (n= 127) and 73% males (n=332). 15% of students (n=67) identified as students typically underrepresented in engineering (female and male African American, Hispanic, Native American and multicultural students; referred to as underrepresented minority students, or URM, in our college), while 5% of students (n=21) chose not to answer this question. 13% of students (n=61) identified as first-generation college bound, or students who are the first in their family to attend college. Most engineering majors offered at the university are represented. Two sections received no training in team dynamics (n=48), four sections received one hour of training in team dynamics (n=94), and fourteen sections received more than one hour of training in team dynamics (n=320). Overall, there were nine professors for the 20 sections over five semesters, with some professors who teach only in the fall or spring, while others teach every semester.

Instrument Design

Our primary source of data came from an online engineering attitudes pre/post survey given to students enrolled in the class. This survey asked a variety of questions, including the students' ranking of certain technical skills and professional skills on a five-point Likert-type scale ranging from "not at all" to "definitely." The survey also asked general identifying questions, such as gender, ethnicity, demographic, class section, class standing, etc. The pre-semester survey contained 133 items relating to prior experiences, motivation, attitudes, interests, and demographics; the post-semester survey repeated the 89 attitude and interest items. Items from the Academic Pathways of People Learning Engineering Survey (APPLES) was incorporated into the FYEP survey, which includes measurements of students' self-estimates of knowledge of engineering and skills related to engineering design work (26 items from the 89 total attitude and interest items on the survey).[15] The FYEP survey, including these borrowed APPLES items, had been previously validated with the attitude items (n=89) and had an internal reliability using Cronbach's Alpha of 0.97 (a value exceeding 0.7 is thought to be adequately reliable).[14]

Surveys for all participating students were conducted under the University's Institutional Review Board (IRB) approval and reviewed annually by external and internal evaluators. Student responses were coded to protect participant identity.

Variables in the Analysis

The two dependent variables that were examined in this paper included students' self-estimates of their technical skills and professional skills. These 26 survey items asked students to answer the question, "Please rate how well prepared you are to incorporate each of the following items while practicing as an engineer." Technical skills (10 items) included applying the design loop, data analysis, and problem solving, while professional skills (16 items) included presentation skills, teamwork, and management skills, among others. Other variables collected for this analysis included semester and section of the course for which the student was enrolled, gender, ethnicity, and a status of first-generation college-bound student.

In order to model and numerically consider the impact of the various levels of team dynamics training on students' perceived technical and professional skills (from no training to more than one hour of training), multiple proxy variables were created (see Table 1). The first proxy variable, *TeamTrain_1hr*, represents students who received one hour of team dynamics training during the semester (n=94). The second variable, *TeamTrain_1+hrs*, represents students who received more than a single hour of team dynamics training and intervention over the course of the semester (n=320). And, finally, the group that both of these variables was compared to is enrollment in *No Training*, or no help with team dynamics over the course of the semester (n=48).

Table 1. Revised proxy variables for hours of team dynamics training, used in analysis.

Variable	Number of students (Female, URM, FirstGen)
TeamTrain_1+hrs	320 (88, 47, 50)
TeamTrain_1hr	94 (27, 13, 7)
No Training	48 (12, 7, 4)

Statistical Analysis

As stated previously, we focused on students' self-perceived professional and technical skills from pre- to post-semester. First, we queried professors on how much team dynamics training they gave to their students and whether or not they would be willing to share the results of how well teams did in the class they taught. We used this information to group students between the semesters of fall 2010 and fall 2012 into our proxy variables.

Each participant's score for the professional and technical skills items on the pre- and post-surveys were averaged to result in a single composite score for each factor. We also assigned a value to the participant's gender (Gender), whether or not the student identified as an underrepresented minority (URM), and whether or not the student identified as a first-generation college-bound student (FirstGen). Participants were assigned the appropriate proxy variable of how much team dynamics training their section of the course received. Next, each set of survey responses was paired pre to post for each individual.

The data was examined for missing values and data entry errors. We removed students who did not complete either a pre or post survey from the data set prior to analysis. Any missing values in the remaining data set were examined for patterns, and no student skipped more than two items in each administration of the survey. Paired sample t-tests were used with each analysis to determine mean, standard deviation, correlations, and paired differences. Repeated measures of analysis of variance (ANOVA) were used when appropriate to examine the differences among relationships of variables. IBM SPSS® predictive analytics software was used for all analyses in the paper.

Results

The survey results reported in this paper were from matched pre to post surveys of 462 students enrolled in 20 sections of FYEP over five academic semesters (fall 2010 through fall 2012). Previous research in first-year engineering projects indicated that project-based learning increases the knowledge and design skills of students.[15, 16] This analysis supported similar results. Specific to this research is the amount of training received in team dynamics. The trends for student responses based on different amounts of team dynamics training received are displayed in Table 2 and graphically in Appendix A.

Table 2. Results by Amount of Team Dynamics Training.

Cell entries contain mean scores (standard deviations), mean difference, and post-survey effect sizes for overall student participation in First-Year Engineering Projects on variables of interest.

Variable	N	Pre Survey Mean (SD)	Post Survey Mean (SD)	Mean Difference
Professional Skills				
All	**462**	**3.62 (0.57)**	**3.79 (0.59)**	**0.17***
Team Training 1+hrs	320	3.63 (0.57)	3.78 (0.61)	0.15*
Team Training 1hr	94	3.62 (0.53)	3.85 (0.51)	0.23*
No Team Training	48	3.54 (0.63)	3.74 (0.60)	0.20*
Technical Skills				
All	**462**	**3.36 (0.61)**	**3.73 (0.58)**	**0.37***
Team Training 1+hrs	320	3.36 (0.61)	3.74 (0.59)	0.38*
Team Training 1hr	94	3.32 (0.56)	3.67 (0.55)	0.35*
No Team Training	48	3.39 (0.68)	3.75 (0.60)	0.36*

*Significant at the $p<0.05$ level, paired t-test

There were significant gains in perceived technical and professional skills, similar to the overall course, with all students in various amounts of team dynamics training. Interestingly, the students who had no team dynamics training randomly started with higher initial perceived technical skills, while students in the sections that received team dynamics training had higher initial perceived professional skills. Subsequent analyses did not find significant differences for changes in mean scores between the three groups. In other words, students in all groups had similar changes in perceptions over the course of the semester. This indicates that while some greater gains in skills were identified, team dynamics training did not offer a statistically different result than the non-team dynamics training on perceived technical and professional skills.

Demographical Impact on Team Dynamics Training

In an effort to understand the impacts of emerging instructional practices in team dynamics on different demographics of students, we analyzed our data set with respect to gender, underrepresented minority (URM) identification, and first-generation college-bound student status. These patterns again resembled the overall team dynamics training results found in Table 2 (see Appendix B). In other words, all of the targeted groups had increased scores for both professional and technical skills over the course of the semester. The amount of team dynamics training *did not* negatively impact any student scores. While the targeted female, URM, and first-generation students in the section of the course with no team dynamics training had slightly better mean gains than their peers, the number of participants for these groups was small (n=12, n=7, and n=4, respectively).

Qualitative Focus Group Results

While quantitatively there does not appear to be any difference between student perceptions of skills and the amount of team dynamics training they receive during their first semester, anecdotally, we heard from students that there is a difference in *how* teams work together. In order to clarify our survey findings, we conducted a student focus group in February 2013 (for students who were previously enrolled in the FYEP courses). The focus group questions included discussion on how much training they had, how well their teams worked together, and the success of their final project.

Focus group results helped clarify the minimal differences in our quantitative results. Students agreed that the course helped improve their teamwork skills and reported learning more about teamwork while actually working with their teams during the semester than they learned from instructor-led team dynamics training. This suggests that there is a large amount of team dynamics training that is unintentional in FYEP, equalizing the teamwork experience across treatment groups. For example, students related, “I think (how to work in a team) was one of the things I learned in class. The whole semester was (spent) building on our team relationship and learning how to work together” and “At the beginning of the class they made us read literature about what it means to be part of a team, what teams do together, meetings, etc… but I think what really was the most valuable part of the class came when we physically had to just get down to it and do work on the project.”

Interestingly, students also often referenced a lack of understanding around how important the team dynamics training they received would be, mentioning they would have taken the training more seriously if they had known how it would help their success in the class. “I wasn’t quite aware of the impact the training could have in creating a successful semester. I just kind of thought it was another team building exercise because it was the first year of college for me and I thought, you know, this is just another way for the school to create happy people, like another icebreaker activity." "I don't think I realized at the time how much it would help. Like working with a team, knowing how to deal with certain types of people, but it definitely has."

As we anticipated, student focus groups told us about team struggles and dynamics and how much of their skills were a result of team project success. We also learned more about how well the training in team dynamics helped their experience, including the students' realization that the training was helpful after the course was over.

Limitations of Study and Suggestions for Future Research

The results presented in this paper are not without limitations. First, study participants are comprised of only students who take the FYEP course at the University of Colorado Boulder's College of Engineering and Applied Science. Not all majors have FYEP as a course requirement at this time, and, consequently, not all students take the course during their undergraduate engineering education. Only a fraction of the instructors (9/20, or 45%) who taught FYEP between fall 2010 and fall 2012 responded to our query on the amount of team dynamics training offered during their courses, which further limited our study population.

Due to the low faculty response, we have very few participants in the "no team dynamics" category (only one instructor responded that they did not offer the students any team dynamics training). However, those students had some of the highest gains in self-rated professional and technical scores. Since the scores are the product of a single professor, we cannot determine if the results are truly generalizable across sections with no training in team dynamics.

The literature provides copious examples of project-based learning resulting in increased skills acquisition. We analyzed these desired outcomes as self-ranked technical and professional skills. It would be useful to analyze other proxies for success in a team-based course.

While there were no added gains in students' perceived professional and technical skills from training in team dynamics, there is also no suggested decrease in the skills associated with higher amounts of team training. Focus group results suggested the enduring impacts of team dynamics training on other coursework in engineering; however, it would be useful to conduct more focus groups with students who are several years out of the course with more real-world teamwork and intern experiences.

Despite these limitations, we feel the results of this analysis are useful to other instructors of similar design projects courses for first-year engineering undergraduate students. It would be useful to extend this study to all entering FYEP students to see if the trends persist.

Conclusion

Our initial results actually disprove our predictions and support the null hypothesis. While there is an improvement in professional and technical skills over the course of the semester for all students, there was no significant improvement of these skills based on the amount of team dynamics training the participants had received or students' demographics of gender, ethnicity, or first-generation college-bound status.

The results of our focus group mirror our survey results and also provide support for more intentional team dynamics training throughout the semester. One student suggested bringing all the teams back together throughout the semester and discussing potential issues: “At this point, this is how a team should be going, and these are things that you can improve.”

For this research, we looked at the first-year engineering projects course at the University of Colorado Boulder’s College of Engineering and Applied Science over five semesters and how instructors incorporated team dynamics training. We feel that the results of this analysis are useful to other instructors of similar design projects courses for first-year engineering undergraduate students in determining the amount of class time to spend on training teams to work together—even if the team is not perfect. Perhaps it is best for the students to repeatedly revisit team dynamics strategies throughout the course rather than only during structured class time at the beginning of the semester. We recommend instituting team dynamics training intermittently throughout the semester that would coincide with problems teams may be having, as evidenced by Bacon’s work (forming, storming, norming, performing and adjourning).[11]

In conclusion, the key findings from this research reveal that while there is not a substantial increase in reported professional and technical skills, there is no indicated decrease in the skills associated with greater amounts of team dynamics training. Students do not realize the importance of the team dynamics training they receive at the beginning of the semester but acknowledge the impacts of developing these skills during the months and years following. This suggests that early team dynamics training may in fact result in long-term benefits for team performance during an individual’s collegiate and post-collegiate career.

References

[1] Knight, D.W., Sullivan, J. F., and B. Louie (2007). "Expanding Understanding of First-Year Engineering Student Retention and Team Effectiveness Through Social Styles Assessment." In *Proceedings*, American Society for Engineering Education Annual Conference and Exposition, June.

[2] Teamwork. (n.d.). In Business Dictionary online. Retrieved from http://www.businessdictionary.com/definition/teamwork.html

[3] Williams, K. L. “What Is Team Dynamics?” (14 June 2011). Retrieved from http://www.livestrong.com/article/354170-what-is-team-dynamics/

[4] The Accreditation Board for Engineering and Technology. (2011). Criteria for Accrediting Engineering Programs. The Engineering Accreditation Commission. Retrieved from http://www.abet.org/uploadedFiles/Accreditation/Accreditation_Process/Accreditation_Documents/Current/eac-criteria-2012-2013.pdf

[5] Laguette, S. (2010). “Development of High Performance Capstone Project Teams and the Selection Process.” In *Proceedings*, 2010 American Society for Engineering Education Annual Conference and Exposition, June.

[6] Bielefeldt, A. (2009). “Cognitive Diversity and the Performance of Freshman Engineering Teams.” In *Proceedings*, 2009 American Society for Engineering Education Annual Conference and Exposition, June.

[7] Jensen, D., Feland, J., Bowe, M., and B. Self (2000). “A 6-hats Based Team Formation Strategy: Development

and Comparison with an MBTI Based Approach." In *Proceedings*, 2000 American Society for Engineering Education Annual Conference and Exposition, 81–96, June.

[8] Talley, A., White, C., Wood, K., and R. Crawford (2010). "Designing and Teaching Interdisciplinary Curriculum: Investigating Innovation and Our Engineered World." In *Proceedings*, 2010 American Society for Engineering Education Annual Conference and Exposition, June.

[9] Feland, J. M. (2002). "Building Teammates: Bringing Better Team Skills to Design Courses." In *Proceedings*, 2002 American Society for Engineering Education Annual Conference and Exposition9643–9655, June.

[10] Bannerot, R. (2005). "Characteristics of Good Teams." In *Proceedings*, 2005 American Society for Engineering Education Annual Conference and Exposition, 1641–1651, June.

[11] Bacon, D. R., Stewart, K. A., and W. S. Silver (1999). "Lessons From The Best And Worst Student Team Experiences: How A Teacher Can Make The Difference." *Journal of Management Education*, *23*(5), pp. 467-488, October.

[12] Loughry, M.L., Ohland, M.W., and D.D. Moore (2007). "Development of a Theory-Based Assessment of Team Member Effectiveness," Educational and Psychological Measurement, 67(3), pp. 505-525.

[13] Hunter Sr., K. W., Matson, J. O., and L. R. Dunn (2002). "Impact of a Fifty-minute Experiential Team-building Program on Design Team Performance." In *Proceedings*, 2002 American Society for Engineering Education Annual Conference and Exposition, 9163–9171, June.

[14] Zarske, M. S., Reamon, D. T., Bielefeldt, A. R., and Knight, D. W. (2012). "Service-Based First Year Engineering Projects : Do They Make a Difference ?" In *Proceedings*, 2012 American Society for Engineering Education Annual Conference and Exposition, June.

[15] Sheppard S.D., Gilmartin, S,, Chen, H,L,, et al. (2010). "Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES)." *Engineering*, 2010, September.

[16] Knight, D. W., Carlson, L. E., and Sullivan, J. F. (2007). Improving Engineering Student Retention through Hands-On, Team Based, First-Year Design Projects. *International Conference on Research in Engineering Education* (pp. 1-13). Honolulu, HI.

Appendix A. Graphical Representations of Professional and Technical Skills by Amount of Team Dynamics Training

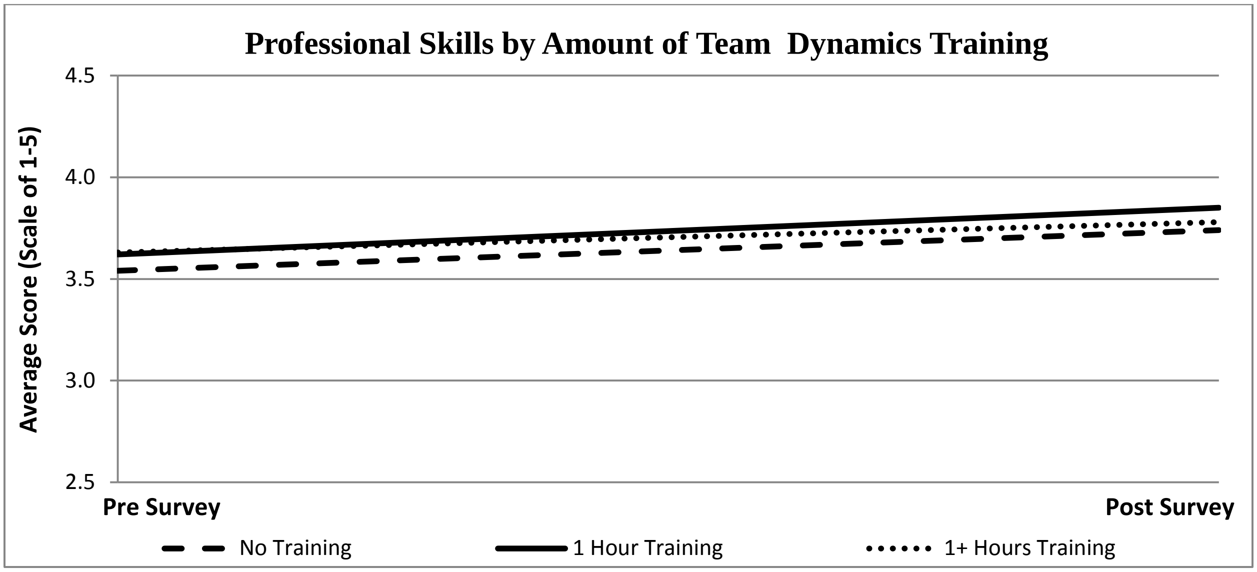

Figure A.1. Graphical Representation of Professional Skills by Amount of Team Dynamics Training

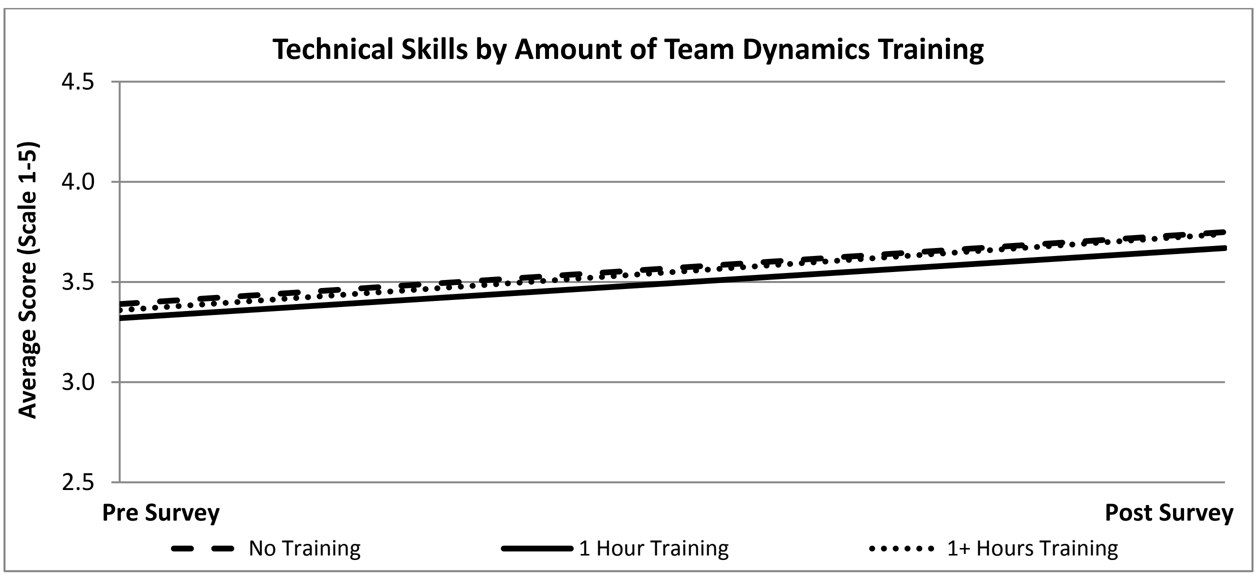

Figure A.2. Graphical Representation of Technical Skills by Amount of Team Dynamics Training.

Appendix B. Results of Data Analysis by Variable of Interest

Table B.1. Results by Amount of Team Dynamics Training and Gender

Cell entries contain mean scores, (standard deviations), mean difference, and post-survey effect sizes for overall student participation in First-Year Engineering Projects on variables of interest.

Variables		N	Pre Survey Mean (SD)	Post Survey Mean (SD)	Mean Difference
Professional Skills					
	Female-Overall	**127**	**3.76 (0.48)**	**3.91 (0.50)**	**0.14**
	Team Training 1+hrs	88	3.79 (0.51)	3.93 (0.59)	0.14
	Team Training 1hr	27	3.79 (0.58)	3.87 (0.53)	0.08
	No Team Training	12	3.51 (0.66)	3.82 (0.41)	0.31
	Male-Overall	**332**	**3.57 (0.57)**	**3.74 (0.60)**	**0.17**
	Team Training 1+hrs	231	3.57 (0.59)	3.72 (0.61)	0.15
	Team Training 1hr	66	3.56 (0.50)	3.84 (0.51)	0.28
	No Team Training	35	3.57 (0.63)	3.74 (0.65)	0.17
Technical Skills					
	Female-Overall	**127**	**3.23 (0.59)**	**3.68 (0.57)**	**0.45**
	Team Training 1+hrs	88	3.25 (0.58)	3.70 (0.56)	0.45
	Team Training 1hr	27	3.20 (0.57)	3.47 (0.59)	0.27
	No Team Training	12	3.16 (0.7)	3.96 (0.54)	0.80
	Male-Overall	**332**	**3.41 (0.61)**	**3.75 (0.59)**	**0.35**
	Team Training 1+hrs	231	3.41 (0.62)	3.75 (0.61)	0.35
	Team Training 1hr	66	3.37 (0.56)	3.75 (0.52)	0.38
	No Team Training	35	3.52 (0.60)	3.70 (0.61)	0.19

*Significant at the $p<0.05$ level, paired t-test

Table B.2. Results by Amount of Team Dynamics Training and Ethnicity

Cell entries contain mean scores, (standard deviations), mean difference, and post-survey effect sizes for overall student participation in First-Year Engineering Projects on variables of interest.

Variables	N	Pre Survey Mean (SD)	Post Survey Mean (SD)	Mean Difference
Professional Skills				
URM-Overall	**67**	**3.68 (0.57)**	**3.88 (0.53)**	**0.20**
Team Training 1+hrs	47	3.71 (0.60)	3.91 (0.57)	0.21
Team Training 1hr	13	3.70 (0.45)	3.82 (0.40)	0.13
No Team Training	7	3.50 (0.65)	3.78 (0.54)	0.28
Majority-Overall	**374**	**3.62 (0.57)**	**3.77 (0.60)**	**0.15**
Team Training 1+hrs	260	3.62 (0.57)	3.75 (0.62)	0.13
Team Training 1hr	75	3.63 (0.55)	3.84 (0.53)	0.21
No Team Training	39	3.58 (0.63)	3.78 (0.60)	0.20
Technical Skills				
URM-Overall	**67**	**3.44 (0.60)**	**3.76 (0.53)**	**0.33**
Team Training 1+hrs	47	3.52 (0.65)	3.81 (0.55)	0.29
Team Training 1hr	13	3.26 (0.34)	3.67 (0.46)	0.40
No Team Training	7	3.19 (0.51)	3.65 (0.55)	0.46
Majority-Overall	**374**	**3.35 (0.61)**	**3.71 (0.59)**	**0.36**
Team Training 1+hrs	260	3.33 (0.61)	3.71 (0.60)	0.38
Team Training 1hr	75	3.35 (0.57)	3.66 (0.56)	0.31
No Team Training	39	3.47 (0.67)	3.81 (0.60)	0.34

*Significant at the $p<0.05$ level, paired t-test

Table B.3. Results by Amount of Team Dynamics Training and First Generation College Bound Status

Cell entries contain mean scores, (standard deviations), mean difference, and post-survey effect sizes for overall student participation in First-Year Engineering Projects on variables of interest.

Variables		N	Pre Survey Mean (SD)	Post Survey Mean (SD)	Mean Difference
Professional Skills					
	1st Generation-Overall	**61**	**3.71 (0.64)**	**3.81 (0.65)**	**0.10**
	Team Training 1+hrs	50	3.73 (0.64)	3.80 (0.69)	0.07
	Team Training 1hr	7	3.63 (0.64)	3.68 (0.49)	0.05
	No Team Training	4	3.63 (0.70)	4.16 (0.42)	0.54
	Not 1st Generation-Overall	**397**	**3.61 (0.56)**	**3.79 (0.58)**	**0.18**
	Team Training 1+hrs	268	3.62 (0.56)	3.78 (0.60)	0.16
	Team Training 1hr	86	3.62 (0.52)	3.86 (0.51)	0.23
	No Team Training	43	3.55 (0.63)	3.72 (0.60)	0.17
Technical Skills					
	1st Generation-Overall	**61**	**3.47 (0.63)**	**3.66 (0.68)**	**0.19**
	Team Training 1+hrs	50	3.49 (0.66)	3.66 (0.70)	0.17
	Team Training 1hr	7	3.31 (0.37)	3.46 (0.54)	0.15
	No Team Training	4	3.56 (0.71)	4.04 (0.40)	0.48
	Not 1st Generation-Overall	**397**	**3.34 (0.60)**	**3.74 (0.57)**	**0.40**
	Team Training 1+hrs	268	3.34 (0.60)	3.76 (0.57)	0.42
	Team Training 1hr	86	3.32 (0.58)	3.69 (0.55)	0.36
	No Team Training	43	3.41 (0.64)	3.74 (0.61)	0.33

*Significant at the $p<0.05$ level, paired t-test