Impact of a Fifty-Minute Experiential Team-Building Program On Design Team Performance

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Abstract

Team-building programs that utilize experiential learning have been proven effective and their use is becoming widespread in industry. Programs can range in length from several hours to several days, and those that incorporate periodic follow-up activities have been shown more effective. However, most engineering courses are so packed with technical content that it is difficult to find time to incorporate experiential learning programs as part of teamwork instruction. This paper describes an experiential team-building program that can be presented in a single fifty-minute class period and applied in classes with large enrollments. A summary of the program objectives, activities, and facilitation guidelines is included. The paper also presents the results of a study involving over 300 freshmen engineering students on 42 design teams. The study addressed the question: Does the addition of a fifty-minute experiential team-building program significantly improve course outcomes as defined by student knowledge of teamwork, student attitudes about teamwork, and project quality? Pre- and post-project surveys and project grades were used to assess the impact of the program.

1. Introduction

As the practice of the profession of engineering changes, so does the education of new engineers. Over the past twenty-five years, engineering design education has evolved with the addition of many new topics, including:

- powerful computer-aided engineering tools for design and analysis;
- the concepts of concurrent engineering, sustainable engineering, life-cycle engineering, and accessibility; and
- a diverse array of topics that relate to the context and environment in which design is practiced, such as global and societal issues, project management, and teamwork.

The pedagogy of design education has likewise evolved with the integration of design throughout the curriculum and increased emphasis on capstone design courses and team design projects.

The current ABET Criteria for Accrediting Engineering Programs requires that graduates possess a wide range of knowledge and abilities, including "an ability to function on multi-disciplinary teams."[1] Most undergraduate engineering programs utilize team design projects as a means of demonstrating compliance with this criterion, and some programs also include formal instruction in teamwork issues.

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For the past three years, the authors have utilized experiential learning programs for teamwork and leadership development in a variety of industrial engineering courses.[2] Team-building programs that utilize experiential learning have been used with success in both the corporate and military sectors. Programs can range in length from several hours to several days, and those that incorporate periodic follow-up activities have been shown more effective.[3] However, most engineering courses are so packed with technical content that it is difficult to find time to incorporate experiential programs as part of team-building instruction. This paper describes an experiential team-building program that can be presented in a single fifty-minute class period and applied in courses with large enrollments. The paper also presents the results of study involving over 300 freshmen engineering students on 42 design teams. The study addressed the question: Does the addition of a fifty-minute experiential program significantly improve course outcomes as defined by student knowledge of teamwork, student attitudes about teamwork, and project quality?

2. Program Design

The program was developed as a workshop for design teams in a freshman introduction to engineering course and was based on a framework used by the authors for a number of other teamwork and leadership programs.[2] The framework consists of four steps:

1. Defining the program goals.
2. Selecting the program exercises.
3. Framing the exercises.
4. Debriefing participants with emphasis on application.

The goal of the workshop was team building, i.e., helping teams to quickly progress through the forming and storming stages of team growth and into the performing stage. The authors' experience with freshmen design project teams indicated that the workshop should address issues of socialization, development of team norms, communications, decision making, planning, and problem solving.

To address these issues, three exercises were selected: a socialization activity, a team charter activity, and a team initiative. Table 1 provides a summary of the workshop content and schedule.

Table 1. Workshop Content and Schedule.

Exercise	Issues Addressed	Minutes Allotted
Socialization	Communications	10 for exercise 5 for facilitation
Team Charter Activity	Development of team norms	10 for exercise 5 for facilitation
Team Initiative: Big Business	Planning Decision making Problem solving Communications	10 for exercise 10 for facilitation

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Since the students were primarily first-semester freshmen and were randomly assigned to teams, it was unlikely that many of the students would know more than a few members of their teams. The socialization activity required the team members to form pairs, quickly interview their partner, and then introduce their partner to the rest of the team. This activity was allotted ten minutes. At the conclusion of the activity, a brief review of the importance of knowing one's teammates was presented. The review focused on communications improvement and the effective use of personnel resources.

The team charter activity required teams to develop a team mission statement, a set of team goals, and a list of team norms. This activity was allotted ten minutes and then the teams were instructed to complete the exercise as homework and turn it in at the next class meeting. Following this exercise, there was a brief discussion of the importance of the team charter and how it could be used to keep team members on track during the project. The importance of good communications was again addressed.

The final activity was a team initiative, called Big Business, that required teams to quickly design and construct a tower of LEGO® blocks while trying to optimize a cost function that included tower height, number of blocks used, and time used.[4] Teams were given a mandatory five-minute planning period and then a timed period of up to five minutes for construction. Following this exercise, the debriefing focused on planning, decision making, problem solving, and communications.

All exercises were framed in the context of the freshman design project, and debriefing comments were related directly to team performance on the design project. Although debriefing of experiential learning activities usually involves a facilitated reflection on the team's performance and discussion of the related issues, the time constraints of this workshop required an abbreviated debriefing that focused only on key issues. Even with the limited time available, a few student comments were solicited in order to prevent the perception of a lecture.

As previously cited, experiential learning programs that incorporate periodic follow-up activities have been shown more effective.[3] A set of three follow-up activities was also developed as part of the project. These five-minute activities required teams to report on project progress and team growth and development.

3. Experimental Design

All undergraduate engineering programs at Tennessee Technological University share a common freshman year, the Basic Engineering Program. One of the courses in the freshman year is BE 1210 - Introduction to Engineering, a typical overview course that exposes students to a variety of engineering topics including engineering design, teamwork, and a team design project. This study utilized three fall semester sections of BE 1210 to investigate the impact of the fifty-minute experiential team-building program on design team performance. Students were randomly assigned to teams of eight in each section. All sections received a fifty-minute lecture on the basic concepts of teamwork. Two sections received the experiential team-building workshop, and one of those received the series of follow-up activities during the next three class periods. Table 2 provides a summary of the experimental design. Pre-project surveys were

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conducted prior to the teamwork lecture, and post-project surveys were conducted after the project was completed.

Table 2: Teamwork Instructional Components by Course Section.

BE 1210 Section	Teamwork Lecture	Team-building Workshop	Follow-up Activities
001 (T-Th, 10:00 a.m.)	X	X	
002 (T-Th, 1:00 p.m.)	X	X	X
003 (T-Th, 2:00 p.m.)	X		

The pre-project survey was designed to collect demographic information, quantitative information about various types of prior teamwork experience and teamwork education, ratings of overall experiences with and attitudes about teamwork and team projects, and ratings of personal knowledge of fundamental teamwork concepts and personal teamwork skills. Other information collected prior to the project included composite ACT scores and high school core grade point averages. The post-project survey was designed to collect quantitative information regarding changes in knowledge of fundamental teamwork concepts and personal teamwork skills, ratings of overall experiences with and attitudes about teamwork and team projects, ratings of design team performance in various categories, and ratings of the effectiveness of various team-building techniques. Design project grades, design project success as evidenced by a working prototype, and the number of teamwork questions correctly answered on the final exam were also collected to assess the workshop impact.

4. Analysis and Findings

The analysis focused on three main issues: pre-project student characteristics, pre-project section characteristics, and post-project results.

4.1 Pre-Project Student Characteristics

Table 3 presents the baseline information on the academic preparation of the students who participated in the project, and Table 4 provides the results from the survey questions on prior teamwork experience and instruction. The first seven results shown in Table 4 are based on answers to survey questions on the number of times the student had participated in team projects and had received instruction on teamwork.

Table 3. Student Academic Characteristics.

Characteristic	Average
Number of students surveyed	344
High school core GPA	3.33
Composite ACT	24.9

Overall, the results of the pre-project survey were surprising. Students indicated that they had had significantly greater numbers of teamwork experiences than expected by the authors. Particularly surprising were the number of teamwork experiences in a work environment and the number of times they had received formal teamwork instruction.

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Table 4. Student Teamwork Experience and Prior Instruction.

Survey Question	Average # of Times
# of teamwork experiences in prior coursework	5.3
# of teamwork experiences in extracurricular activities	7.9
# of teamwork experiences in a work situation	4.3
# times (total) of participation in formal teamwork instruction	3.2
# times of participation in formal instruction in preparation for team project	2.7
# times (total) of participation in team-building programs	2.5
# times of participation in team-building programs in preparation for team project	1.7

Table 5 provides the remaining pre-project survey results related to experience with and attitudes about teamwork. The choices for answers for the first four questions in Table 5 were (1) very positive or excellent, (2) positive or above average, (3) neutral or average, (4) negative or below average, and (5) very negative or very limited.

Table 5. Student Pre-Project Self-Assessment of Preparation For and Attitude Toward Teams.

Survey Question	Average Response	Approximate Result
Overall experience with teamwork	2.2	More Positive than Neutral
Knowledge of teamwork concepts	2.6	Average to Above Average
Personal skills for teamwork	2.4	Average to Above Average
Overall attitude toward teamwork	2.2	More Positive than Neutral
% of prior successful team projects		83%

4.2 Pre-Project Section Characteristics

Conclusions about the effect of the team-building workshop on design project performance can be considered valid only if there were no significant differences in the three sections initially with respect to student abilities and teamwork background. Table 6 shows the results of Fisher's least significant difference tests at the 95% confidence level for comparison of means of student performance characteristics. Table 7 provides the results of the same statistical test for comparing pre-project survey means related to teamwork experience and prior instruction.

Table 6. Pre-Project Section Comparison on Student Performance Characteristics.

Item (Average)	Section 1	Section 2	Section 3	Statistical Test
High school core GPA	3.32	3.37	3.30	No differences
Composite ACT	24.94	25.13	24.53	No differences

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Table 7. Pre-Project Section Comparison on Teamwork Experience and Prior Instruction.

Item (Average)	Section 1	Section 2	Section 3	Statistical Test
# of teamwork experiences in prior coursework*	3.10	3.12	3.06	No differences
# of teamwork experiences in extracurricular activities*	4.07	4.04	3.81	No differences
# of teamwork experiences in a work situation*	2.57	2.91	2.79	No differences
# times (total) of participation in formal teamwork instruction*	2.28	2.47	2.46	No differences
# times of participation in formal instruction in preparation for team project*	2.12	2.32	2.24	No differences
# times (total) of participation in team-building programs*	2.03	2.21	2.26	No differences
# times of participation in team-building programs in preparation for team project*	1.74	1.78	2.04	Section 3 > Section 1
Overall experience with teamwork	2.22	2.31	2.08	Section 2 > Section 3
Knowledge of teamwork concepts	2.49	2.64	2.61	No differences
Personal skills for teamwork	2.23	2.50	2.37	Section 2 > Section 1
Overall attitude toward teamwork	2.22	2.32	2.14	No differences
% of prior successful team projects	4.37	4.28	4.31	No differences

* Choices were (1) none, (2) 1-3, (3) 4-6, (4) 7-9, or (5) 10 or more.

Only three questions on the survey resulted in responses with significant differences between two sections, but even these differences were not consistent between sections. Students in section 3 had participated in more team-building programs in preparation for a team project than had students in section 1. Students in section 2 rated their overall experience with teamwork less positive (higher mean) than did students in section 3 and rated their personal skills for teamwork weaker (higher mean) than did students in section 1. Since the results are not consistent between sections and no other differences were apparent, it was concluded that section differences were negligible. Thus, the effects of the different treatments for teamwork instruction could be tested without bias.

4.3 Post-Project Results

Following the project, students completed a post-project survey with questions about their team experience. These responses and project performance metrics were used to assess the effect of the workshop and follow-up activities.

The hypothesis of the experimental design was that both attitudes about teamwork and project performance metrics could be improved by adding an experiential learning workshop. Because prior research has shown that follow-up activities are desirable to enhance teamwork knowledge,

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greater improvement was expected for the section having both the workshop and follow-up activities.

Unfortunately, the results from the survey and project performance metrics are mixed. Table 8 provides a summary of responses on students' overall attitude toward teamwork. All of the sections had improved attitudes, but the greatest improvement occurred for section 1, the section that had the workshop without follow-up activities. The least improvement occurred for the section that experienced the workshop plus follow-up.

Table 8. Comparison of Pre-Project and Post-Project Attitudes Toward Teamwork*.

Survey Question: Overall Attitude Toward Teamwork	Section 1: Lecture Plus Workshop	Section 2: Lecture Plus Workshop With Follow-up	Section 3: Lecture Only-- No Workshop	Statistical Test
Pre-Project Average	2.22	2.32	2.14	No Differences
Post-Project Average	1.91	2.12	1.93	No Differences
Difference	0.31	0.20	0.21	

*Choices were (1) very positive, (2) positive, (3) neutral, (4) negative, or (5) very negative.

Students were also asked to compare their experience on the design project with their previous team experiences, and Table 9 provides a summary of the results. Students in sections 1 and 3 rated their BE 1210 design project experience better than did students in section 2, with a statistically significant difference between sections 1 and 2. These differences may have been related to team performance on the project. Table 10 provides a summary of average project grades, average percentages correct on the teamwork questions on the final examination, and percentage of teams that successfully demonstrated a working prototype. Again, section 1 performed better overall than either sections 2 or 3.

Table 9. Comparison of BE 1210 Project Experience With Other Team Projects*.

Survey Question: BE 1210 Versus Other Team Experiences	Section 1: Lecture Plus Workshop	Section 2: Lecture Plus Workshop With Follow-up	Section 3: Lecture Only-- No Workshop	Statistical Test
Average Response	2.21	2.54	2.27	Section 2 > Section 1

*Choices were (1) significantly better than others, (2) better than others, (3) about the same, (4) not as good as others, or (5) significantly worse than others.

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Table 10. Comparison of Project and Exam Performance by Section.

Design Project and Teamwork Performance	Section 1: Lecture Plus Workshop	Section 2: Lecture Plus Workshop With Follow-up	Section 3: Lecture Only--No Workshop	Statistical Test
Project Grade Average	87.3	81.7	80.36	Section 1 > Section 2 Section 1 > Section 3
Final Exam Teamwork Questions (% correct)	79.1	78.7	77.6	No Differences
Working Prototype (% of teams)	85.7	66.7	69.2	

4.4 Effectiveness of Instructional Methods

Another question on the post-project survey asked students to rate potential instructional methods for teamwork. Table 11 provides a summary of the student ratings by section. It is interesting that all sections rated a workshop on teamwork as being the most effective method; lectures on teamwork were uniformly rated as least effective. This is perhaps the most encouraging result related to the experiment.

Table 11. Ratings of Instructional Methods for Improving Team Performance*.

Instructional Method	Section 1: Lecture Plus Workshop	Section 2: Lecture Plus Workshop With Follow-up	Section 3: Lecture Only--No Workshop	Statistical Test
Lectures on teamwork	2.22	2.18	2.20	No Differences
Workshop on teamwork	1.66	1.79	1.76	No Differences
Weekly follow-up activities on teamwork	1.87	1.98	1.80	No Differences
Weekly team self-assessment reporting	1.74	2.13	1.81	Section 2 > Section 1 Section 2 > Section 3

*Choices were (1) highly effective, (2) somewhat effective, or (3) neutral or not effective.

5. Conclusions

The hypothesis of the experimental design was that both attitudes about teamwork and project performance metrics could be improved by adding a fifty-minute experiential learning workshop. All sections reported improved attitudes about teamwork, performance metrics were higher for the sections receiving the workshop, and all sections selected the workshop as the most effective means of teamwork instruction. It is not clear, however, that the project treatments (i.e., workshop and follow-up) led to the improved results. Confounding factors may have included class section meeting time, student perception of teamwork knowledge versus actual knowledge, and team success in demonstrating a working prototype. Future studies will focus on refining the

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workshop, incorporating weekly team self-assessments, and developing a pre-workshop test for evaluating teamwork knowledge and skills.

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