EVALUATION OF THE EFFECTIVENESS OF DESIGN TEAM-BUILDING: A 45-MINUTE INVESTMENT PAYS OFF

Dale A. Wilson, M. Christine Miller, Karthikeyan Subbiah
Tennessee Technological University

Abstract

This paper discusses an experiment to determine whether team-building activities could influence the outcome of student group projects in a senior mechanical engineering machine design class. This educational experiment was an offshoot of a 3-year ongoing investigation of factors that influence the costs of new product development. The results from this preliminary investigation show that the student groups that had 45 minutes of team-building exercises turned in higher quality design projects.

Introduction

Educators often assign group projects to students. The ABET Criteria 2000 states that it is important that engineering graduates have "an ability to function on multi-disciplinary teams." Industry says that it wants graduates who can function as team players. Yet, students are seldom given guidance on how to make a group effort function effectively. In the business management literature, there is a concept termed the 'nominal group.' This describes the situation where a group effort is merely the sum of the group members' individual efforts. But the real strength in groups or teamwork is the ability to develop synergy, where the total group effort is *greater* than the sum of its individual parts [1-3]. The educational experiment described in this paper was undertaken in the spirit of seeing whether professors can use training (in the form of team-building activities) to help students obtain that desired synergy in their group projects. Since engineering professors often have difficulty finding enough class time within the semester to cover all the technical topics that they believe students require, the experiment described below involved a very modest amount of class time for group training activities (a mere 45 minutes).

This educational experiment was an offshoot of work currently being undertaken on a three-year grant funded by the National Science Foundation and the Air Force Manufacturing Technology Directorate (ManTech). The grant is focused on identifying factors which influence the costs incurred in the new product development process (nonrecurring cost, as distinct from product cost). The research team is an interdisciplinary team comprised of four university professors, two engineering and two business faculty. Three companies have agreed to be industrial partners in this study, representing three industries (airframe, automotive, and airborne electronics).

As part of the grant, the research team has been collecting information from its industrial partners regarding which factors enable or inhibit the effectiveness of cross-functional new product development teams. A key starting assumption was that product development costs might increase if the cross-functional teams utilized in concurrent engineering did not function effectively. These increased costs might manifest themselves in the form of budget overruns,

missed deadlines, or a suboptimal product design. Thus, one area in which the researchers are interested is the role that training plays in helping employees become effective cross-functional team participants.

Course Description

The course that was chosen for this design team-building experiment was a senior machine design class. This course included a conceptual design project that represented 20% of the class grade. This project would be developed in two parts. A preliminary design was required shortly after mid-term and each project was evaluated and feedback was given. A final conceptual design was required at the end of the semester. To start this process, the class of 29 students was divided into three groups. These groups did a brainstorming session to decide what mechanical device was needed or needed improvement. Once the groups decided on a problem statement, each group was randomly divided into two competing design teams. One of each of these teams would receive team training.

The total project grade was determined by ½ for the preliminary design and ½ for the final conceptual design. Each design included an oral presentation and a written report. These were weighted ⅓ for the oral presentation and ⅔ for the written report. This grading system had a minor influence on the results as will be discussed below.

Project Mechanics

On three separate occasions, half of the student team participated in fifteen-minute sessions focused on team-building activities; the other half listened to presentations on product development. All students were told that this was an experiment to see if selected business topics could enhance the objectives of the engineering design class, and that their feedback on the value of these sessions would be solicited at the end of the semester.

During the first team building session, near the beginning of the semester, the student groups were instructed to think about well-functioning groups that they had observed in the past, then to make a list of the factors that contributed to making those groups work well. (Some examples of contributing factors: People attend all group meetings and arrive on time. Group members are willing to compromise. The work is shared equally.) The lists developed by each group were then typed up and distributed back to the students. Each group was given the list that they themselves had developed, as well as the lists developed by the other groups.

In the second team building session, a week later, the student teams were told to develop a list of group rules; in other words, to explicitly spell out their expectations of each other and how group members will conduct themselves. Some examples of group rules: Be flexible about the times that you are willing to meet. Ask for everyone's ideas and opinions. Don't interrupt when other people are talking.

The third team building session took place around mid-semester. At this point, all teams had prepared and been graded on a preliminary design report, so they had more experience working

together. The students were instructed to reexamine the original set of group rules that they had developed at the start of the group project. Was this set of rules functioning adequately? Did they wish to make additions or modifications?

All of the above exercises were designed (1) to get students to think about what was involved in teamwork and being a good team member, and (2) to encourage discussion of these topics among the group members. Beyond that, it was left to the discretion of each student group as to whether or not they actually implemented their own suggestions. In carrying out this experiment, the professors' intent was be as inobtrusive as possible regarding the internal functioning of each team, not to 'police' or monitor their actions. Instead, the professors chose to examine the project group outcomes.

If there was a clear trend of better project outcomes from the student groups that received the team training, relative to the control groups which did not, then it would be a plausible assumption that the team-building exercises may have had a positive influence on group performance. Thus, the conclusions would be based upon association (correlation) rather than strict cause-and-effect. This is the imperfect nature of many behavioral experiments. Skeptics desiring to conduct their own more rigourous experiment, with tigher monitoring and controls on the student groups, are free to pursue this.

Results and Discussion

The raw data from the design class students is shown in Table l. Teams 1,3, and 5 had team training. This was an exploratory study, designed to work with the sample that was available. Due to the small sample size of 6 teams, both parametric and nonparametric analyses were performed. Nonparametric methods are designed for the analysis of smaller samples (especially samples with under 30 observations)--situations where there may be insufficient statistical power to obtain statistical significance from the more traditional parametric methods. The data was evaluated for grade point average and team training to determine if these variables were a significant influence on project outcome. The statistical analyses performed on the data showed that the differences in the project outcome could not be attributed to grade point. A parametric and nonparametric analysis of the data did show a significant influence of team-building experience on the project outcome. The ANOVA gave an F-value of 9.26 and $P<.01$. The nonparametric Wilcoxon 2-Sample Test [4] reported a significant difference at a confidence level of approximately $p=.01$.

Team 1 competed against Team 2 on the same design problem statement. Likewise Team 3 competed against Team 4 and Team 5 completed against Team 6. In two of the competitions the team that received the training clearly out performed the competition. In the other competition (Teams 3 and 4) the trained team had a better design outcome but had a lower project grade because the team had misinterpreted the written report requirements for the preliminary design (which accounted for 33% of the total grade). Also, Team 4 had the highest grade point of any team in the class. Other observations were that the team self-evaluations for the team trained students were generally higher and these students' experience was more positive than their experience in past student projects.

TABLE 1 - Raw Student Data					
Name	**GPA**	**AVG GPA for Group**	**Course Grade**	**Team Self Evaluation**	**Project Grade**
Team 1					
Member A	3.273		B	92.2	92.5
Member B	2.476		C	89.8	92.5
Member C	3.540		B	92.0	92.5
Member D	3.087		A	97.2	92.5
Member E	3.813	3.2378	A	91.6	92.5
			3.2		
Team 2					
Member F	2. 571		C	87.6	84
Member G	2.680		B	88.6	84
Member H	3.522		B	89.8	84
Member I	3.214		B	89.6	84
Member J	1.966	2.796	F	73.0	84
			2.2		
Team 3					
Member K	3.441		B	95.0	89
Member L	3.738		B	94.0	89
Member M	2.565		C	92.0	89
Member N	3.892		A	90.0	89
Member O	3.524	3.432	A	93.0	89
			3.2		
Team 4					
Member P	3.252		C	94.6	90.5
Member Q	3.324		B	89.0	90.5
Member R	3.636		A	87.6	90.5
Member S	3.357		B	90.2	90.5
Member T	3.888	3.4914	A	96.4	90.5
			3.2		
Team 5					
Member U	3.725		A	95.0	87
Member V	2.429		C	93.3	87
Member W	3.802		A	97.3	87
Member X	2.585		D	84.3	87
Member Y	2.122	2.9326	C	90.7	87
			2.6		
Team 6					
Member Z	3.883		A	94.5	84
Member AA	2.380		C	85.5	84
Member BB	3.393		A	93.5	84
Member CC	3.519	3.28125	B	91.5	84

			3.25		

Conclusion

Understandably, this is a small data set, but the authors believe that the 45-minute investment paid dividends. Potentially a larger investment of time would yield a more significant improvement in project outcome and would be worth exploring further.

Acknowledgments

The authors gratefully acknowledge the support provided for related research by a grant from the National Science Foundation and the Air Force Manufacturing Technology Directorate (ManTech), which lead to this educational experiment. The authors would also like to acknowledge the support of Dr. John Burhnam for product development presentations to the control group.

References

1. Jon R. Katzenback and Douglas K. Smith, "The Discipline of Teams," *Harvard Business Review*, March-April 1993, pp. 111-20.

2. Carl E. Larson and Frank M.J. La Fasto, *TeamWork: What Must Go Right/What Can Go Wrong* (Newbury Park, CA: Sage Publications, 1989).

3. Stephen P. Robbins and Mary Coulter, *Management*, 5th Edition, pp. 506-14, (Upper Saddle River, NJ: Prentice Hall, 1996).

4. Sidney Siegel, *Nonparametric Statistics for the Behavioral Sciences* (NY: McGraw-Hill, 1956).

DALE A. WILSON
Dr. Dale A. Wilson is a Professor of Mechanical Engineering at Tennessee Technological University . He received his B.S. (1974), M.S. (1975) and Ph.D. (1978) from the University of Missouri-Columbia. Prior to joining Tennessee Technological University he spent 6 years in Mechanics of Material and Structures at Pratt & Whitney Aircraft Group. He is a member of ASEE, ASME, ASTM, ASM International and Sigma Xi. He teaches Machine Design and Mechanical Behavior of Materials and does research in related areas.

M. CHRISTINE MILLER
Dr. Christine Miller is an assistant professor in the Decision Sciences and Management Department, College of Business Administration, at TennesseeTechnological University. She received a Ph.D. in business management from the University of Houston in 1994. Her current research projects focus on cross-functional new product development teams, and managerial decision making in small business firms.

KARTHIKEYAN SUBBIAH
Karthikeyan Subbiah is a candidate for a Doctoral Degree in Engineering at Tennessee Technological University. He holds a Master's Degree in Mechanical Engineerng from the same school. Currently, he is involved in the NSF-Funded Research entitled, "Innovation, Implementation and Cost."