Coaching Engineering Design Teams

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Introduction

At an increasing rate, teams are becoming the primary unit of performance in industrial organizations.[1] In line with this trend, representatives from industry have requested, and engineering educators have responded, that graduating seniors in engineering need to have a greater ability to work in teams[2, 3]. Although the University of Tennessee, Knoxville provides a team based design experience throughout the senior year, faculty who have taught these classes have experienced recurring problems with teamwork[4]. With the goal of improving the teamwork skills within these senior design teams, a program has been developed between the College of Engineering and the Counselor Education and Counseling Psychology Unit (CECP) of the College of Education.

This program has involved the pairing of two groups of students. One group was composed of senior engineering students who were enrolled in a senior capstone design sequence in mechanical engineering. As a part of this class, these students were to meet throughout the spring semester to work in design teams on a problem provided by industry for the purposes of creating a realistic environment for the use of their engineering skills.

The second group of students were graduate students who were affiliated with the CECP unit within the College of Education. These students were enrolled in a graduate level course which placed them with their respective design teams. Graduate students who were allowed to enroll in the course had to either be doctoral students in Counseling Psychology or have completed a group dynamics course in CECP.

Program Design

The program was designed to be a two part process. The first phase of the project focused on communications training. Using a combination of principles from learning style theory[5] and human motor behavior theory[6], Seat et al. created a communications training program custom designed for engineering students. This training was conducted toward the end of the first semester (Fall semester, 1996) and used three class periods to focus on three topics. The first topic focused on learning to question to get information. The second session taught the effective presentation of ideas. Finally, the goal of the third session was to put the previous two skills sets to use in a debate session so that the trainees could learn to have differences of opinion without conflict.

In the second phase of the program, the CECP graduate students were designated in the role of "coaches" and met with their respective design teams once a week during the Spring semester of 1997. In addition, coaches met once a week with a CECP faculty member to discuss the progress with their teams and discuss appropriate interventions. Following principles proposed by Schwarz,[7] the "coaching role" called for coaches to remain neutral to the content of the design project. Therefore, they were to have no input on grades and minimal contact with the professor of the design class. Thus, the presence of the coaches was designed to be as "transparent" as possible to the instructor of the design course.

The active portion of their role required the coaches to make observations of the teams' dynamics and communications patterns and feedback this information to the teams. In addition, the coaches were to help the team to use this information to further the development of their previously learned communication skills, and to design more effective ways of working together. The coaches accomplished these goals through the use of structured and unstructured approaches. For the more structured approaches, coaches led brainstorming sessions for problem-solving and scheduled practice sessions for the teams' final presentations. In a more unstructured fashion, coaches met with design teams while they worked on their project and intervened when they deemed it necessary.

<u>Program Evaluation</u>

The present study was part of an evaluation plan for investigating the effectiveness of the coaching program. The overall goal of the study was to compare coached and uncoached design teams on selected dimensions of group dynamics. In order to provide an overview of these dimensions using proper terminology it is necessary to use the words <u>group</u> and <u>team</u> interchangeably. The dimensions selected for evaluation purposes were from theory and instrumentation developed by Bales. [8] He proposed that group dynamics could be understood by locating individual team member's self-ratings on a two-dimensional field diagram represented by two axes: task orientation and team orientation scores. Task orientation scores refer to a team member's acceptance of and desire to perform correctly the procedures set up by external authorities. High scorers on this dimension are very concerned with doing things in the prescribed manner. Lower scorers on the task orientation scale can be characterized as more interested in challenging established procedures, preferring to innovate or change the existing order of things. Team orientation scores discriminate between group members who behave in a more self-interested and self-protective way on the lower end of the scale and those who are more cooperative and protective of others on the high end. To add more understanding to his model of group dynamics, Bales added a third dimension entitled dominance. Dominance scores are representative of a team member's amount of participation, status, and personal influence in the group. Bales [9] has found that the most effective teams consistently score in the upper right hand quadrant of the field diagram indicating both a positive task orientation and a positive team orientation.

Parke and Houben[10] developed a computerized method of scoring and presenting this information. Figure 1 presents a sample field diagram generated by their program. Team members scores on the x and y axes are plotted at their corresponding positions on the diagram. Circle size is representative of a team member's dominance scores. In addition, these researchers have added a fourth measure entitled average distance which is indicated by the larger circle around all of the team members' scores. This is a measure of how cohesive the team is and indicates similar points of view on task and team orientation. Teams with lower average distance scores are labeled unified whereas teams with higher scores are either fragmented (e.g., coming apart) or polarized (e.g., taking sides). Parke and Houben have found that more cohesive teams demonstrate better team performance.

Using the SYMLOG scales the researchers wanted to obtain measures of team performance across the semester. Given Bales' and Parke and Houben's findings that effective teams consistently score higher in both task and team orientation and demonstrate better cohesion, the researchers in the present study expected the coached engineering design teams to maintain more consistently positive task and team orientation scores than the uncoached design teams. In addition, it was expected that coached teams would demonstrate lower average distance scores on the measure of group cohesion.

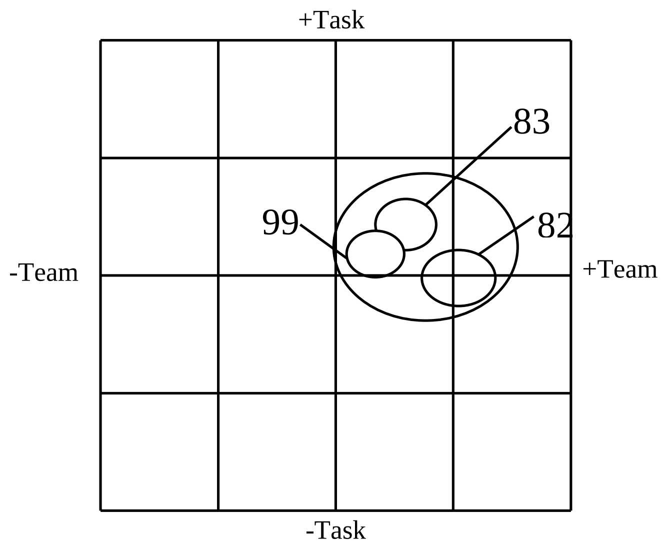

Figure 1: Sample SYMLOG Field Diagram

Procedure

The participants in the present study were 36 individuals who were enrolled in a senior capstone design sequence in mechanical engineering. 32 of the participants were male. The instrumentation chosen for this study was developed by Bales, Cohen, & Williamson[11] and is most commonly known by the acronym SYMLOG which stands for the Systematic Multiple Level Observation of Groups. The SYMLOG instrument makes use of an eighteen item adjective checklist. Respondents are asked to rate themselves or other team members according to how they see themselves or others in their team. Each of the eighteen items consists of an adjective followed by a series of five responses ranging from "never" to "always". The adjective checklist is designed to yield scores on three dimensions: task orientation, team orientation, and dominance. The SYMLOG scales have demonstrated both acceptable internal consistency and interrater reliability estimates. In addition, evidence for the concurrent and construct validity of the SYMLOG scales has been established.[12]

One section of the class was chosen to be a control group, while the two remaining sections were designated as the experimental group. There were 19 participants in the experimental group and 18 participants in the control group. At the end of the fall semester of the year long design class the engineering students in the experimental group received the communications training. During the first week of the spring semester both experimental and control groups were separated into design teams with three to four participants to the team. The participants in both the experimental and the control groups were administered the SYMLOG instrument during the second week of the spring semester after they had been assigned to their teams. The coaches in the experimental group met with their teams once a week for sixteen weeks. During the fifteenth week of the semester, just prior to their final design project presentation, both experimental and control groups were again administered the SYMLOG instrument. SYMLOG data was scored using the computerized program developed by Parke and Houben.

Results and Discussion

Data from the team orientation and task orientation measures was subjected to a repeated measures analysis of variance procedure, and a significant difference was found between the two groups on the team orientation scale as shown in Table 1. The control group demonstrated a significant drop between the pre- and post-test on the team orientation scale whereas the experimental group maintained consistent scores. Neither experimental nor control groups demonstrated a significant change on the task orientation scale. A repeated measures analysis of variance procedure was also run on the average distance scores as shown in Table 2. A significant difference was not found between the two groups, although the data were in the right direction. Nonsignificant results were likely affected by the small sample size (n=10). One of the experimental groups was eliminated from the data for results which will be discussed later.

The results of this investigation provided partial support for the original expectation that coached engineering design teams would maintain more consistently positive scores on measures of task orientation and team orientation than uncoached design teams would. Specifically, the results were consistent with the expectation that coached teams would perform better on the team orientation scale. That is, just prior to the presentation of a crucial project, uncoached engineering design teams demonstrated a significant drop in a measure of their cooperation, positive attitude, and general orientation toward their team. Coached teams maintained consistent scores on the team orientation dimension. However, another of our expectations was not supported. Both experimental and control groups maintained a consistent task orientation throughout the semester. It would not appear that a coach would be necessary to keep senior level students in engineering design teams focused on the task.

The mean of the "average distance" scores for non-coached teams was +.67 indicating less group cohesion at the end of the semester than at the start, while for coached teams this number was -.71 indicating more group cohesion. While the difference between these two numbers was statistically insignificant due to sample size, significant information can be obtained from this analysis by referring to the field diagrams plotted in Figure 2 and Figure 3. These diagrams represent coached and uncoached teams respectively at the pre and post test. As is typical most engineering design teams will plot in the upper right hand quadrant indicating positive task and team orientation. As indicated, uncoached teams move to the left in the quadrant demonstrating lower team orientation. Another consistent pattern is that the average distance circles surrounding the coached teams become smaller indicating a more unified team while the circles surrounding the uncoached teams become larger indicating a fragmented team.

Another interesting pattern noted by the diagram is the presence of an outlier indicated by student 81 in the coached group and student 37 in the uncoached group. These scores are on the

Table 1
Means for task orientation and team orientation

	Task pre	Task post	Change	Team pre	Team post	Change
Coached						
Team 1	2.17	1.83	-.34	7.33	7.83	.50
Team 2	5.00	3.83	-1.17	6.50	8.33	1.83
Team 3	3.50	3.83	.33	8.33	8.33	.00
Team 4	2.16	1.66	-.50	1.50	2.16	.66
Team 5	1.75	1.75	.00	6.60	6.38	-.22
Total	2.92	2.58	-.34	6.85	7.41	.56
Uncoached						
Team 6	2.75	2.25	-.50	5.63	2.87	-2.76
Team 7	2.83	2.66	-.17	5.83	2.66	-3.17
Team 8	1.87	1.87	.00	6.87	6.50	-.37
Team 9	.33	1.66	1.33	6.66	5.17	-1.49
Team 10	3.37	3.00	-.37	4.50	4.75	.25
Total	2.23	2.29	.06	5.89	4.39	-1.50**

n=34 **$p \leq .05$

Table 2
Average distance scores

	Pre-test	Post-test	Change
Coached			
Team 1	4.37	3.32	-1.05
Team 2	2.92	1.41	-1.51
Team 3	3.92	3.12	-.80
Team 4	2.44	1.52	-.92
Team 5	2.24	2.97	.63
Total	3.18	2.47	-.71
Uncoached			
Team 6	2.63	1.13	-1.50
Team 7	.53	3.63	3.50
Team 8	2.85	3.05	.20
Team 9	2.50	2.42	-.08
Team 10	3.03	4.66	1.63
Total	2.31	2.98	.67

n=10

edge of the average distance circle and represent a team member who likely feels alienated from the team. It can be noted that in the coached group the outlier became more unified with the group while in the uncoached group the outlier stayed on the edge of the circle and became less team and task oriented.

Implications and Future Research

The implications of this study are twofold. First, there is the request from industry that graduating seniors in engineering have greater team skills. From the results it would seem that by interacting with the CECP coaches, engineering students acquired exposure to the requisite interpersonal skills to maintain a positive team environment. Second, there is the concern expressed by engineering faculty over the recurring interpersonal problems with their teams. It would seem that the presence of coaches in the teams to help with team skills can reduce the amount of time instructors have to spend resolving interpersonal problems. This should free instructors to focus more on instructing on the task.

The present study contained a sample of 37 participants. This was a small sample and any future study should increase the number of teams. Also, one coach was eliminated from the study whose scores indicated an outlier. This coach was not affiliated with CECP program. Although the researchers made attempts to ensure quality of the coaches, greater efforts could be made in the future to ensure coaching expertise. In addition, future research could use other measures than SYMLOG. Assessments could be made of individual differences in coaching style and its effect on team performance.[13] Finally, the final grades on the design team projects might be included in the evaluation process.

Summary

Responding to requests from industry that graduates in engineering should have a greater ability to work in groups, a program was developed placing graduate students in counseling psychology as facilitator/coaches of senior level design teams in an engineering department. In evaluating the program the researchers found a useful tool in the SYMLOG assessment device which presents a number of dimensions of team performance on a field diagram. The program evaluation indicated that uncoached control groups demonstrated a significant decrease across the semester on a measure of cooperation whereas facilitated teams remained constant. However, both groups remained constant on a measure of task orientation. The results led to the conclusion that while design teams are able to maintain task orientation independently, they need a facilitator to help them to stay together and remain cooperative.

Acknowledgment

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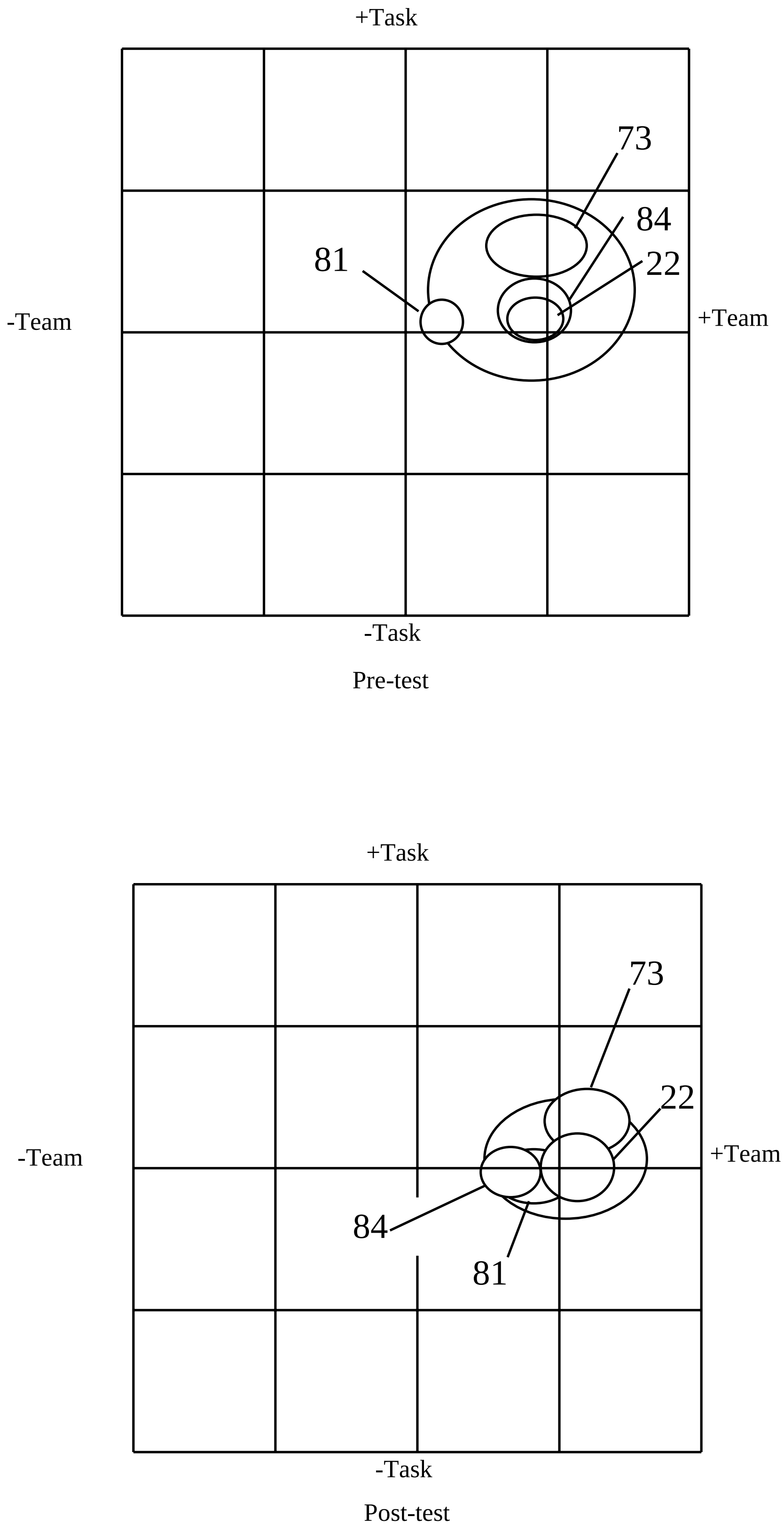

Figure 2: SYMLOG Field Diagram - Coached Team

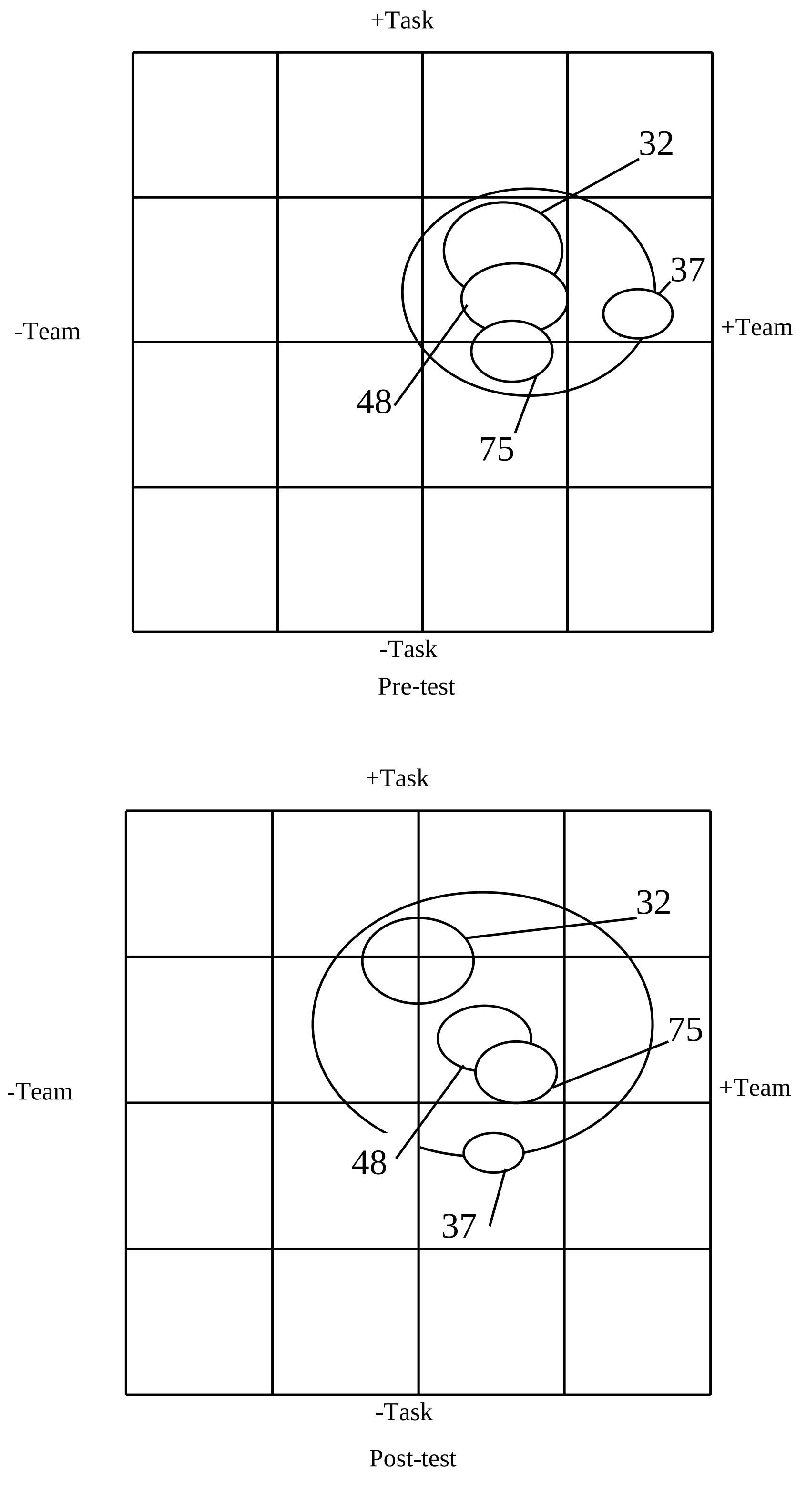

Figure 3: SYMLOG Field Diagram - Uncoached Team

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