# 2006-937: ENGINEERING STUDENTS' PERCEPTIONS OF ATTITUDE CHANGES IN TEAMWORK

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# Engineering Students' Perceptions of Attitude Changes in Teamwork

Introduction and Literature Review:

The ability to work efficiently on technical teams is an essential skill for engineers. In recognition of the importance of this skill, many engineering education programs have added technical team experiences to their curriculum. This study investigated how students perceive the importance and utility of these experiences by exploring the ways in which students' attitudes toward group work changed through experiences on technical teams. For the purposes of this study, the terms "team" and "group" will be used interchangeably.

ABET, the accreditation board for university programs in applied sciences, computing, engineering, and technology, identified communication skills and teaming as two important qualities students should develop during their engineering education. It is no longer enough for engineering students to graduate with technical skills and sufficient knowledge. They must have the skills and abilities necessary to communicate effectively and function adequately on interdisciplinary teams[1, 2]. As a result, many engineering programs now devote a portion of their curriculum to team experiences and building communication skills. These activities are designed not only to equip students with the interpersonal skills that they will need in their career, but to build self-efficacy and help increase retention[3].

The Engage program at the University of Tennessee was designed to be an integrated curriculum that would "continue to teach essential skills, using techniques that improve problem-solving ability, teach design methodology, and teach teamwork and communication skills,"[4]. The Engage program is a 12 credit hour, two-semester course that all first year students are required to take. The program was piloted in the 1997-1998 academic year and has continued to grow and develop.

One of the key components of the program is team projects. Students are placed into four to six member teams and given various projects throughout the course of the year. The teams are formed based on several different factors. First, personality type is considered, as identified by the Myers-Briggs Type Indicator, so that each team has members with various personality types. Next, ACT scores and gender are considered. Historically, higher ACT scores were grouped together and lower ACT scores were grouped together. Teams were arranged so that those teams with female members had at least two females in the group.

The team projects correspond with the concepts and skills students are learning in their classes and working with in their homework assignments. Through these projects the students are presented with opportunities to practice oral and written reports, project planning, and idea generation and selection. They are also presented with concepts such as team rules and roles, communication skills, and group dynamics[4]. These concepts are presented throughout the year, along with exercises and prompts for team discussion. For example, when group norms are discussed, the teams are led in an exercise where they list the norms that exist for their team. Graduate students in Counseling Psychology travel between teams, facilitating discussion and group processing. Team time is

structured so that students have time to reflect on group dynamics and interpersonal factors that influence successful project completion. This focus helps reinforce the team time and develop and solidify skills in working with technical teams.

This study was designed to explore the ways in which students perceive team experiences and the impact of these experiences on attitudes toward teamwork and its relevance to engineering. It is not unusual for students to express uncertainty about working on teams or to question the necessity of group projects. It is widely recognized that the skills gained from working on teams are important for engineers to possess. Therefore, it is essential that students not only gain these skills, but understand the need for them[2]. This study examines student's perceptions of the ways in which their attitudes towards teams changed over the course of the academic year.

This study was designed as survey research. With survey research, the ability to draw causal inferences from the data is not permitted[6]. Additionally, this study only investigated attitudes and perceptions of the engineering students from an anonymous perspective; therefore, only specific attitudes can be evaluated from this type of research design[6]. The survey was designed in order to reflect the attitudes and perceptions that were impressed upon and taught to the students during this one year course. Thus, the purpose of the study was to elucidate the students' attitudes about their experiences in groups as the curriculum is currently structured. This implies that the survey measures what the group facilitators and faculty members implementing this program view as fundamental and core learning objectives for the students and how the students reacted to these teachings.

There is a paucity of literature and theory related to group processes and outcomes for technical teams. For this analysis, there were five overarching categories conceptualized, each assessing a different set of skills or attitudes related to engineering and groups. The categories were Attitudes Towards Groups, Attitudes Toward Diversity, Knowledge of Strengths and Weaknesses, Perceptions of Engineers and Groups, and Specific Group Skills. These categories were based on an integration of literature from therapeutic group processes and outcomes and the specific learning objectives as conceptualized by the group facilitators and faculty members associated with the Engage program.

Concerning Attitudes Towards Groups and Perceptions of Engineers and Groups, ABET, as mentioned previously, views teamwork as a primary skill for engineers[1,2]. For this reason, objectives for the course centered upon stressing the importance of teamwork skills in the field of engineering to the students. Attitudes Toward Diversity reflects a perspective from the group processes and outcomes literature[7]. Corey and Corey (1999) suggested that cultural diversity is a fact of life in our contemporary world, and, as a group facilitator, you cannot afford to ignore the issue of culture in groups[7]. The faciltators' interactions with the students focused on diversity concerns by giving the students a forum to talk about and reflect upon diversity related issues. Knowledge of Strengths and Weaknesses also arises from the group processes and outcomes literature and suggests that an indicator of groups working well together is when there is a willingness to share strengths and weaknesses, knowing your own strengths and

weaknesses, and giving feedback to others about their strengths and weaknesses[7]. This is viewed as an indicator that cohesion and trust are high and that the group has entered the working and thriving stage of the group process, which leads to better group outcomes[7]. Finally, Specific Group Skills refers to specific engineering skills such as brainstorming, knowing how to resolve conflicts that arise in groups, and understanding the importance of team cohesion. The focus for understanding specific group skills, as originally conceptualized by the facilitators, is on the different stages of the group process. This implies that facilitating the forming, storming, and norming stages of the groups are extremely important in order to reach the crucial working and thriving stages for a group[7]. Groups in the working stage have displayed more positive outcomes than groups that never truly reach this stage of the group process[7].

Various other studies have looked at outcomes of team experiences for freshman engineering students. York (2005) describes the first-year curriculum for engineering students at Virginia Polytechnic Institute and State University. At the end of the program, students were asked to write a paper describing what they had gained from working on design-projects in teams. Students commented that they recognized the work and contributions of their teammates and saw the importance of team efforts in completing projects. York states that the team projects "helped to demonstrate to the students the unique challenges and creative nature of the engineering profession."[8]

A study by Zeligman, Fairweather, and Fisher (2004) focused on analyzing changes in learning outcomes in an introductory core course. The course included design projects and instruction in team skills. Among the many factors they considered were students' communication skills and their skills in working with others. In order to assess these skills, students self-assessed whether or not progress was made in each area due to the course. This method, of directly asking students whether or not the course impacted their attitudes, is similar to the methodology used in this study. And, though the categories are different, they address similar themes and issues within teamwork.[9] This appears to be a widely accepted method for measuring team learning objectives. Another study analyzing a similar course also used self-report surveys to measure the ways in which the course impacted students' feelings toward teams and how the course impacted these attitudes.[10]

Hypotheses:

In order to explore these attitudinal changes, retrospective and current attitudes about group and team work were measured in freshman engineering students. It was hypothesized that the students' current attitudes and perceptions about group work would be more positive than their retrospective attitudes. Additionally, it was hypothesized that the categories and total score would also display a more positive change throughout the semester. The items were broken down into five separate categories, and it was hypothesized that the groupings would result in moderate to strong reliability (e.g., >.70).

Method:

The sample consisted of 243 freshmen engineering students attending the University of Tennessee. There were 261 students registered for the course at the end of the academic year, which resulted in a 93% response rate. The engineering department requires each freshman to enroll in a full year course that focuses on engineering fundamentals. A portion of this course focuses on group work where the students are actively engaged in group projects throughout the entire academic year. Demographically, data was not available for this particular class of engineering students. However, when this investigation was being studied, the investigators were told that the demographic composition of freshmen engineering students at the University of Tennessee has been consistent over the past five years. Thus, a report from 2002[5] discussed the demographic information of these students, which is as follows: 80-84% male, 79-87% Caucasian, 11-13% African American, 1-6% Asian American, average Math ACT score between 26.2-26.8, average composite ACT between 25.5-25.8, and average high school GPA of 3.43.

The students' attitudes and perceptions of group work were assessed by the Engineering Fundamentals (EF) Group Work Survey, developed by the authors. The survey was comprised of 22 statements, seven of which were negatively worded. Respondents indicated their agreement on a 7 point Likert-type scale ranging from strongly disagree (1) to strongly agree (7). Higher scores, except for the negatively worded items, indicate more positive attitudes and perceptions of their experiences with group / team work. When the items were accumulated for total and categorized level score analysis, the negatively worded items were reverse scored.

Psychometrically, Chronbach's alpha coefficient for the entire survey was .85 for the retrospective attitudes and .88 for the current attitudes, thus, showing moderate to strong reliability. With respects to validity, the anonymous nature of the questionnaire did not allow the study to assess criterion-related validity as the survey could not be correlated with any other measure or variable. However, face and content validity seem adequate as the survey covered the range of attitudes that were focused on by the group / team facilitators. The study's assessment of construct validity is limited to the correlation of the hypothesized categories in the survey, which was less than .70 for three of the five categories for both retrospective and current attitudes. A discussion on the implications for the lack of construct validity is addressed in the conclusion section. The correlations and results of the categorized level analysis were summarized in the results section.

In order to study students' perceptions of the importance and utility of such courses, students were administered surveys at the end of the academic year. The survey contained two duplicate sets of questions with the first set asking the students to reflect on their thoughts and attitudes before beginning the class in the fall. These retrospective attitudes were also emphasized orally while instructing the respondents about the nature and objective of the survey. They were then asked to respond to the same statements according to their current thoughts and attitudes at the end of spring semester. The surveys were administered by placing the two sets of questions on the front and back of the paper with the retrospective attitudes on the front side. Concerning confidentiality, the surveys were anonymous as the students were instructed that they were not required to place their names on the survey.

Results:

Due to the nature of the anonymous completion of the questionnaire, the analyses were limited to, statistically, a z-test comparing students' retrospective attitudes about group work with current attitudes concerning group work. Table 1 displays the 22 questions used to assess the students' attitudes and perceptions and the corresponding z-tests for statistical significance. In order to run z-tests, the mean retrospective attitudes were subtracted from the mean current attitudes for each survey question. The difference was then tested against a hypothesized mean of zero after entering the standard deviation of the difference for each question. The differences were tested at a *p*-value of .05. Additionally, Table 1 displays the manner in which the questions were categorized. It should be noted again that the categories were selected before any statistical tests were run or analyzed. In the analyses comparing students' perceptions of attitude changes, the results were viewed from an individual question level, categorized score level, and total question score level.

The results indicated that 18 of the 22 questions resulted in attitude changes that were statistically significant at the .05 alpha level. The z-test results for each individual question were displayed in Table 1. Additionally, all of the questions had mean scores that changed in the direction that were desired from a learning objectives and a priori theoretical perspective. The mean scores were also displayed in Table 1. Therefore, 18 of the 22 questions indicated that the students' perceptions of attitude changes concerning team work changed significantly during the academic year in the hypothesized direction, based on the group / team learning objectives for the one year class, while four of the questions showed changes in the hypothesized direction without being significant attitude changes.

From a categorized items and total score perspective, the results indicated that the students' perception of attitude changes concerning group work changed significantly during the course of the academic year. In other words, when the questions were combined into their respective categories and then as a total score, the changes in perception were statistically significant at a .05 alpha level. These results were not a surprise given that 18 of the 22 questions showed significant changes.

In this analysis, the focus on the categories, statistically, was primarily to investigate the construct validity of the questionnaire. Thus, Chronbach's Alpha correlation coefficients were run for the five categories. These results were detailed in Table 2. However, from the perspective of learning objectives, the focus on the categories was to investigate the group work curriculum and teachings that were used with these students throughout the academic year. In other words, the five categories represented the focus of the curriculum. Through structured, unstructured, formal, and informal discussions with the students, it was the goal to raise their level of awareness and enhance their understanding of strengths and weaknesses, attitudes toward diversity, attitudes toward groups, perceptions of engineers in groups, and specific group skills. Therefore, the categories displayed poor (< .60), adequate (.60-.69) to moderate (.70-.80) reliability.

Discussion:

The objective of this study was to investigate the efficacy of the group work focus in the curriculum for freshmen engineering students. In the curriculum, group work comprised, at the minimum, 75 minutes per week of a six credit hour one semester class focused on teaching engineering fundamentals. It seems important to consider the effectiveness of the group / team work for several different reasons.

First, it constitutes more than one-sixth of the students' curriculum during their first academic year in Engineering, thus ensuring that the students are gaining knowledge and skills about teamwork and the group process seems paramount to the success of the overall curriculum. Second, it is our contention that working in teams and working with people appears to be a necessary skill for engineering students entering the workforce. Therefore, finding a manner in which to reach students and teach teamwork skills is extremely important to individuals involved in creating and implementing a curriculum on group work. Finally, the survey enhances our understanding of how the students perceive the group work focus of the curriculum. In other words, it allows us to determine how we can enhance, modify, or adjust the curriculum in order to better serve the students.

In this study, the majority of the students perceived a change in their attitudes throughout the course of the academic year concerning group work. These results indicate that, for freshmen engineers in the program, the perceptions in attitudes about working in teams changed during the course of the year in a positive direction. We credit the curriculum, our focus on working in teams, and the students for this positive change. This indicates that technical team experiences, combined with an emphasis on communication skills and understanding group dynamics, may help equip students with some of the skills necessary for professionals in the field of engineering.

The most obvious limitation to this study is the collection of retrospective data. It may be difficult for students to accurately remember their attitudes and perceptions at the beginning of the one year course. Currently, the authors are working to duplicate the study without this limitation, by administering the surveys at the beginning of the course and then again at the end of the course. This will lead to more accurate data on attitudinal change.

Another possible limitation concerns the hypothesized categories of statements on the questionnaire. While the categories were based on the overarching objectives of the team facilitators and faculty implementing the curriculum, and group processes and outcomes literature, there was not data to support each of the separate categories. "Attitudes Towards Groups" and "Perceptions of Engineers in Groups / Teams" displayed moderately strong reliability while the other categories only showed adequate to poor reliability. This possibly implicates a re-conceptualization of the survey statements and/or a refinement of the group/team work curriculum. In other words, the statements

may not reflect the ideas that were stressed to the students and/or the curriculum may need to teach these concepts more thoroughly. Another hypothesis is that the five categories are not independent of one another. The evidence for this may be that since the overall reliability of the survey was strong, the concern may rest with having five categories that are not independent of one another or questions that cross over into more than one hypothesized category.

Due to the findings of this investigation the curriculum has been structured more systematically over the past year. This study has displayed a need to target two or three specific skills that are desirable for freshman engineering students while continuing to focus on team building and reflecting on experiences. Overall, however, the strong reliability and adequate content validity displayed for the entire survey shows that the majority of the objectives for the students in the program were consistently assessed in the survey and adequately measured the range of attitudes that were stressed during the academic year.

In conclusion, this study indicates that technical team experiences seem to lead to a positive increase in student's attitudes and perceptions of teams and group work. These positive changes were seen overall, in learning objectives and theoretically based categorizations of group concepts, and, in most cases, at the individual statement level. As communication and team skills become increasingly important in the modern world, these team experiences may become a vital part of engineering education.

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**Table 1:**
*T-tests for Attitude Changes in Team Work by individual question, group level, and total score level (N=243)*

| **Questions** | ***Mean***: Retrospective Attitudes | ***Mean***: Current Attitudes | ***p*** |
|---|---|---|---|
| Group 1: Understanding of Strengths & Weaknesses* | 21.67 | 23.30 | $p < .001$ |
| I am confident in my abilities when working in groups | 5.12 | 5.47 | $p < .001$ |
| I know my strengths, and I how I enhance the group | 4.91 | 5.49 | $p < .001$ |
| I know everything I need to know about working in groups | 3.42 | 3.70 | $p = .002$ |
| I work well on teams | 4.91 | 5.07 | $p = .027$ |
| I am unsure about the areas I need to improve when working in groups** | 3.69 | 3.42 | $p = .007$ |
| Group 2: Attitudes Towards Diversity* | 18.91 | 19.84 | $p < .001$ |
| I believe that there is one right way to do things** | 2.66 | 2.65 | $p = .453$ |
| I appreciate others even when I disagree with them | 4.65 | 5.01 | $p < .001$ |
| I enjoy working with people who are different than me | 4.57 | 4.90 | $p < .001$ |
| I believe that most people are unique | 5.35 | 5.58 | $p < .001$ |
| Group 3: Attitudes Towards Groups* | 15.21 | 16.42 | $p < .001$ |
| I enjoy working in groups | 4.46 | 4.78 | $p = .001$ |
| I prefer to work independently** | 4.60 | 4.27 | $p < .001$ |
| Group work is a waste of time** | 3.19 | 3.02 | $p = .063$ |
| Groups are more important than individuals | 4.55 | 4.93 | $p < .001$ |
| Group 4: Perceptions of Engineers in Groups / Teams* | 18.38 | 19.62 | $p < .001$ |

| | | | |
|---|---|---|---|
| Knowing how to work in groups is an important skill for engineers | 5.44 | 5.84 | $p < .001$ |
| Interacting with classmates is an important part of my education | 4.80 | 5.23 | $p < .001$ |
| Team work is not part of being an engineer** | 2.48 | 2.41 | $p = .252$ |
| Engineers work best alone** | 3.38 | 3.04 | $p < .001$ |
| Group 5: Specific Group Skills* | 23.63 | 24.95 | $p < .001$ |
| The final product is more important than the process of getting there** | 4.42 | 4.08 | $p < .001$ |
| I value hard work | 5.92 | 5.97 | $p = .224$ |
| Being accountable to group members makes me try harder | 5.33 | 5.49 | $p = .012$ |
| I know how to handle problems that arise in groups | 4.52 | 4.91 | $p < .001$ |
| Coordinating ideas and team cohesion are most important when working in groups | 5.28 | 5.67 | $p < .001$ |
| **Total Score*** | 97.80 | 104.13 | $p < .001$ |

* Reverse score items were reversed back when summed into group and total scores.

** These questions represent the reverse scored items from the original questionnaire.

**Table 2**:
*Correlation Coefficients for Grouped Items on the Questionnaire (N=243)*

| **Groups** | ***r*** : Retro Attitudes | ***r*** : Current Attitudes |
|---|---|---|
| Group 1: Understanding of Strengths & Weaknesses | .65 | .62 |
| Group 2: Attitudes Towards Diversity | .50 | .65 |
| Group 3: Attitudes Towards Groups | .71 | .76 |
| Group 4: Perceptions of Engineers in Groups / Teams | .70 | .76 |
| Group 5: Specific Group Skills | .42 | .51 |