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The Effectiveness of the E-Team Approach to Invention and Innovation

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Abstract

Within the last decade, teamwork has become a well-known phenomenon in the US industry. Effective teamwork has led to an increase in productivity, a reduction in costs, a rise in employee involvement and flattening of the organizational structure [1].

This study examines student's attitudes and experiences towards working in teams, with particular attention paid to engineering students participating in entrepreneurial teams. The results of the study suggest that the students' attitudes and experiences were positive towards working in teams. The majority of the students felt they were able to perform effectively in teams and thought that working in teams will be beneficial for preparing them for the workplace. Although students responded positively about their teamwork experience, only half of the students received team training. Some of the students felt indifferent about the usefulness of the team training sessions, which suggests that teamwork training has to be improved.

I. Introduction

Within the last decade, teamwork has become an omnipresent phenomenon in US industrial organizations. Organizations have transitioned to teamwork as a vehicle to increase effectiveness, competitiveness and productivity. The Center for the Study of Work Teams reports that in the year 2000, 80 percent of all Fortune 500 companies expected to have 50 percent of their workers working in teams [2].

This increased desire for employees to function in teams has forced colleges and universities to change the manner in which education is delivered [3]. In a study conducted by the American Society of Mechanical Engineers (ASME), teamwork was ranked as the most important skill that should be mastered by undergraduate level engineering students [3].

Engineering colleges are being pressured by industry not only to provide their graduates with intellectual development and superb technical capabilities, but also to educate their students to work as part of teams, communicate well, and understand the economic, social, environmental and international context of their professional activity [4]. As such, engineering education must help students develop teamwork and communication skills. Coursework should feature multidisciplinary, collaborative, and active learning while taking into account students' varied learning styles [4].

In order to ensure that teamwork and communication skills are being improved in the classroom, the Accreditation Board for Engineering and Technology (ABET), the sole agency in the United States responsible for the accreditation of educational programs leading to degrees in engineering, has revamped the requirements for accreditation, and continually reexamined and re-energized the engineering curricula [5].

According to the ABET Engineering Criteria (EC) 2000, engineering programs in the US must now demonstrate that graduates of their program have the ability to function in multi-disciplinary teams [4]. This ABET requirement led the authors to question how effectively this criteria is being addressed by the NCIIA, a granting agency providing financial resources for multidisciplinary teams. The objective of this study was to assess students' attitudes about teamwork, determine what types of training students received and how prepared students felt to work in teams in the workplace. All students in the survey are participants in the NCIIA course and program grants program.

II. Methodology

The study described here was co-sponsored by the National Collegiate Inventors and Innovators Alliance and the University of Nebraska-Lincoln, Industrial and Management Systems Engineering Department to determine the types of experience students working on entrepreneurial teams were having.

The design and execution of the study took place during the spring 2000 semester, while the analysis was conducted during the summer of 2000 and the reporting of results occurred during the subsequent fall.

The objectives of the study as defined by representatives from NCIIA and UNL were to: examine student’s attitudes toward working in teams, with particular attention paid to engineering students,

- collect information about teamwork procedures from the student’s perspective,
- determine what types of training students were receiving prior to the teaming process and to determine if there was any differences in students' satisfaction with their training experience and efficacy between those receiving training and those who did not, and
- determine how prepared students are to work in teams in the workplace.

A. Participants

To collect this information students participating on entrepreneurial teams (E-Teams) sponsored by grants from the National Collegiate Inventors and Innovators Alliance (NCIIA) were surveyed. Most of the teams participating had been in place for at least one semester and no formal assessment had been conducted. Students were from various majors, ethnic backgrounds and schools. The participating schools were diverse in terms of background, emphasis and status, and included large research institutions; small teaching institutions; a mixture of private and public institutions; several well-known and elite institutions and finally several institutions that are actively experimenting with pedagogical issues.

B. Survey Design

The questionnaire was designed to measure the attitudes of engineering students about utilization of teams in higher education. The survey, divided into four parts, began by asking for demographic information of the participants. This section also asked questions regarding team size, team formation actual usages and preferences, how often they had worked in teams in engineering classes and outside engineering classes, and their role on the team.

The second section dealt with students' attitudes about their teaming experience, especially their satisfaction with and the performance of their team experience. A 5-point Likert Scale was used with responses ranging from Strongly Agree [5] to Strongly Disagree [1].

This section also asked information about teamwork training, whether or not it was provided and the topics covered. Finally, this section asked a series of efficacy questions. These questions dealt with team members' beliefs about their ability to perform effectively, in order to find out if the students felt that their teamwork experience was beneficial in preparing them for

future workplace expectations regarding working in teams. A 5-point Likert Scale was also used to measure students' responses to these questions.

The third section of the survey asked background questions regarding their E-teams. Specially, it asked for a description of their project, how they got involved in the project, how long they had been working on their project, whether or not their team had mentors and if students were familiar with the NCIIA Advanced E-Team grants program.

The final section of the survey measured their satisfaction with the E-Team experience. Students were asked questions about their satisfaction with the support received from their faculty advisor, their satisfaction with the progress they had made, and their experience with the course. Finally students were asked to rate the level of importance for resources made available to them via the NCIIA grant.

C. Data Collection and Analysis

Faculty members receiving Course and Program Grants from the NCIIA were contacted and asked to invite their students to participate in this study. Because teams were geographically dispersed, a web-based survey was utilized.

The data was analyzed using SPSS 10.0 and Chi Square comparisons were made to confirm or reject the hypotheses. Chi square comparisons were utilized because non-random data were expected and chi-square is a non-parametric test. In cases where there was insufficient data to draw conclusions based on the chi-square value, the Fisher's exact test was utilized.

To facilitate increased understanding of the chi-square data, response options were collapsed into smaller categories. Responses of one and two were collapse into the one category, while responses of four and five were collapsed into the five category. The middle response of

three remained the same. This collapse in data aided in reducing the number of empty cells present in the data. The alpha level was set for .05 for all statistical tests.

III. Results

This section presents the results of the data analysis performed in conjunction with this study. This information is presented in the following sections: characteristics of the sample respondents, results of the respondent's attitudes about their teaming experience, results of attitudes about their preparation for the workplace, and an overall summary of the results obtained.

A. Characteristics of the Sample Respondents

There were a total of 159 responses to the survey. Twenty-seven of the responses were removed from the data pool, twenty-five because they were incomplete and two because the respondents were faculty members. The 132 valid respondents came from eighteen schools. Unfortunately there was no way to determine the possible number of participants. The NCIIA records information about faculty not students. Invitations were sent to the faculty member who in turn asked their students to participate. However, we do know that faculty at approximately 45 schools were contacted about participation. It is impossible to tell at this time if this self-selection process of participation presents bias in the results.

The demographic breakdown of the respondents is as follows: 73.5 percent men and 26.5 percent women; 90.2 percent engineering students, 8.3 percent business students and 1.5 percent other. The majority of the respondents were third (47 percent) and fourth (27.3 percent) year white/Caucasian students.

B. Teamwork Experience

Students were asked questions regarding team size, team formation, team roles, course type, and the number of courses in which teams were utilized in the engineering curriculum versus outside of the curriculum. The results indicated that each student is presently a member on approximately 1.45 teams and that the team they referred to when completing this survey was on average comprised of 4.2 members. Regarding team roles, thirty-one percent reported that roles were rotated. Of the remaining students, 26 percent reported that they were team leaders, 26 percent were general members, 9 percent were devil's advocates and few students chose the remaining options.

Throughout the literature on student teams there exists an ongoing debate regarding team formation, specifically whether faculty members should assign teams or whether students should self-select. Students were asked which method was actually utilized and which method they actually preferred. Fifty-three percent of the students were assigned to teams. However, 68.2 percent of the students prefer the self-selection method for choosing their team members.

Students were asked how many courses they had taken within engineering where teams were used, how many courses outside of engineering had they taken where teams had been used and whether or not the course referenced for the study was required. Respondents reported that teams were used in 2.77 of their engineering courses and 1.77 of their courses outside of engineering. Seventy percent of the respondents participated in this study participated via a core required course.

The second section of the survey dealt with the students' overall satisfaction with their teaming experience. Four questions were asked in this section and they are shown in (Table 1). These scores indicate that students were satisfied with their teamwork experience and were indifferent with regards to the whether or not the members of their group/team participated

equally. Engineering students were also asked if they felt teams were an effective way to teach engineering courses and the majority of students responding strongly agreed with that statement. All students were asked if they thought teams in general was an effective way to learn and the averages score was 3.33 indicating that those students were indifferent.

Over half of the students participating (52 percent) received training on effective teaming strategies. Students who indicated that they received training were subsequently asked if they found the training useful and in what specific areas did they receive training. The sentiment of those responding was that the training received was useful (4.04). The most popular topics covered in the team training sessions were Role Definitions (54 percent), Effective Meetings (51 percent), Decision-Making Techniques (47 percent) and Goal Setting (47 percent).

The final series of questions in this section dealt with self-efficacy issues. Self-efficacy deals with team member's belief in their ability to perform effectively. The scores of this section are shown in (Table 2).

Overall, the results regarding students' attributes toward the preparation that teaming provides them for the workplace indicates that across the board students are in strong agreement with all efficacy statements. The results of the survey indicate that students strongly believe that teaming in the classroom has prepared them for the workplace, will contribute to their career success and have provided them with the skill set necessary for success. Specifically students feel strongly that they can communicate, negotiate and resolve conflicts with fellow team members, that overall they respect the opinions of others, and they can work with diverse teams. Unfortunately we do not know composition of the teams they were on at the time the study was conducted.

The results indicated that training did not have much of an impact on the self-efficacy of respondents. A chi square test was conducted to assess whether there was a relationship between the students who received training and those who did not with regards to their self-efficacy. Table 3 shows the Chi Square test values for each comparison between whether or not training was provided and a students' efficacy level. There was no significance found between training and questions fourteen through twenty-two and twenty-four and twenty-five. However, there was significance on question twenty-three which asked students whether or not they felt teaming enhanced their performance skills as an engineering student. To confirm this significance a Fisher's Exact test was run p= .0016 which does support the Chi Square finding. Students were also pleased with the guidance, mentoring and resources received from faculty sponsors.

Finally, it appeared that students working on the same team did not have a clear understanding of the team's objective. This conclusion was determined by asking students to give the name of their team and a brief description of their project. Students working as E-Teams worked on a variety of projects including developing software for cyclists that provides optimal routes for cycling, writing programs for Palm Pilots, increasing the coefficient of performance of a refrigeration cycle, developing an umbrella-like walker, and the design, development and testing of a device that improves the ride quality and suspension articulation of leaf-spring, solid-axle suspension systems.

IV. Conclusions

This study offers a strong indication that participating in teams is indeed necessary and beneficial to an education in engineering. Students find that not only are teams an effective way to learn engineering, the team experience also enhances their preparation for the future. Specifically, the E-Team experience provides students an excellent opportunity to develop and

nurture their teaming skills prior to entering the workplace. These skills include valuable decision-making techniques, goal-setting skills, and communications skills for a diverse work environment.

These findings are encouraging in a day and age where the workplace is becoming both increasingly diverse and increasingly competitive. The conclusion can be drawn that in the near future, students who are not exposed to team learning will not be adequately prepared for the workplace.

However, by the methods in which teams are evaluated, students working in E-Teams for this study are not exhibiting all the characteristics germane to an effective team. Based on the responses to the open-ended questions it appears that some students lacked clarity with regards to the purpose of their team, and were unclear about the tasks in which they were engaged. This conclusion is drawn based on the inconsistencies within a number of teams to the question asking for a brief description of their projects. Members of the same team provided different descriptions. These results lead to the conclusion that students lack a sincere understanding of the characteristics of effective teams. Although students report that faculty members are effective mentors and provide them with guidance and sufficient resources, faculty members must do a better job of providing training on the skills necessary to form, manage and maintain effective teams.

V. References

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