Session 2625

Teaching and Assessing Team Skills in a Senior Level Design Course

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ABSTRACT

Industry wants to hire graduates with good teaming skills. As a result, many universities are introducing projects that require students to work in teams. Unfortunately engineering educators find it difficult to assess a student's team skills adequately. Requiring students to work in teams does not necessarily improve a student's ability to be an effective team member. Engineering educators must decide what teaming skills students need, methods for teaching those skills, and strategies for evaluating them. This paper examines the teaming portion of a senior level mechanical engineering machine design course. Each student in the course is assigned to a team that completes a project sponsored by an industrial partner. The authors discuss successful strategies for assigning, developing, and evaluating team skills.

Students who complete the course are expected to demonstrate an ability to work effectively in teams. The teaming skills that students are expected to demonstrate in this course are as follows: the ability to share responsibilities and duties, take on different roles when applicable, analyze ideas objectively, discern feasible solutions, develop a strategy for action, and build consensus. Course activities are structured to help students acquire these skills. Activities include team building, project management, team management and defining rubrics for evaluating team skills. Assessment of student performance includes peer evaluation, student self-assessment, and portfolio assessment.

INTRODUCTION

Students in ME 460, Machine Design, a senior level, required course have been working in teams on industrial sponsored projects for the past 10 years at Rose-Hulman Institute of Technology. Team projects are an integral part of students' education. Mechanical Engineering students begin working on teams during their freshmen year and are required to do so until they graduate. During the 1997-98 academic year, Rose-Hulman Institute of Technology developed institutional teaming objectives. Because of the many opportunities available for students to work on teams, it was assumed that all students would be able to demonstrate their teaming skills easily. This was not the case. Students were not able to provide evidence that they could work effectively in teams. This paper discusses the desired teaming skills and the course activities that were instituted to improve students' teaming skills.

Students who complete Machine Design are expected to demonstrate an ability to work effectively in teams. The teaming skills that students are expected to demonstrate in this course include: the ability to share responsibilities and duties, take on different roles when applicable, analyze ideas objectively, discern feasible solutions, develop a strategy for action, and build consensus. In order to improve students' teaming skills, specific changes were made in the course instruction. Students participated in team building activities and received instruction on team roles, project scheduling, and group decision making. Self-assessment, peer assessment, instructor evaluation, and portfolio submissions were used to gather information about students' abilities.

SELF-ASSESSMENT

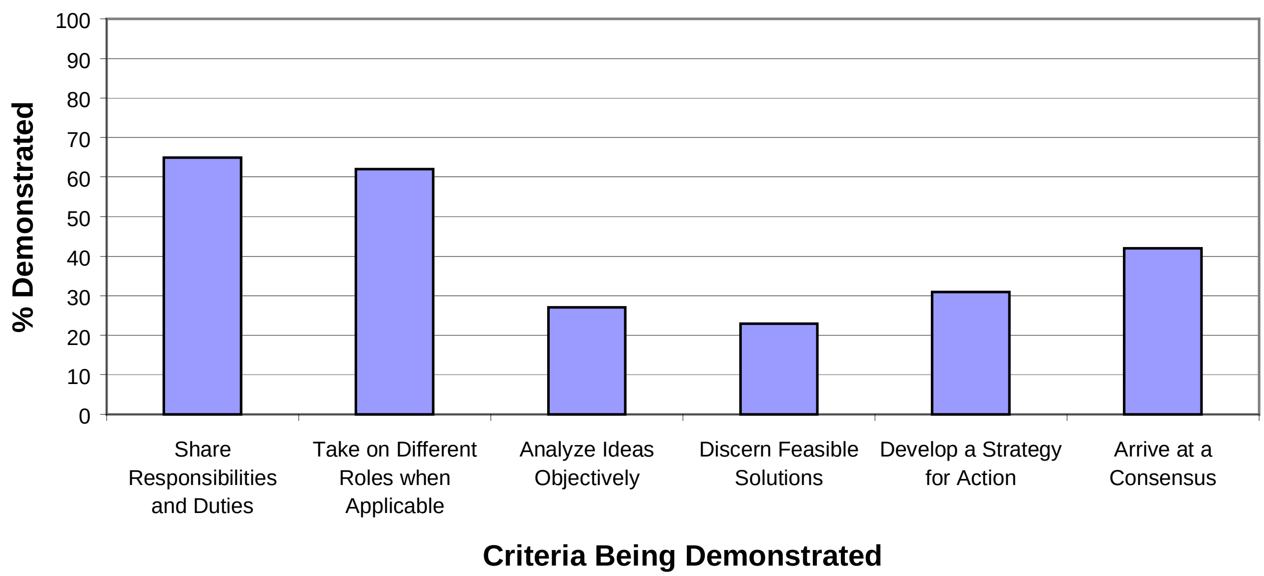
During the winter quarter of 1998-99, students were asked to write paragraphs providing evidence that they were meeting the teaming objectives. Two samples of student work are shown below. Company and student names have been omitted.

> Sample 1: "Throughout our design process I have helped in many ways. I have come up with new and different ideas to help our group solve the design problem presented to us. I have offered suggestions for improvement on other members' ideas. And I helped choose the solution that we will present to Company X. Throughout the design process I have remained objective and impartial and open to other members ideas. Now that we have chosen the design that we will present to Company X my responsibilities are to find figures and drawings as well as discuss the feasibility of its manufacture with outside sources."
>
> Sample 2: "To demonstrate 'Share responsibilities and duties.' We split up the various design tasks so that each team member's duties are more compartmentalized and specific. We broke our machine down into three major parts. They are:
>
> - The motor, pulley, and brush system. This system was designed by Student X. He had to determine motor size and speed, the type of drive belts, where to place an idler pulley, etc.
> - The linear actuator. Student Y was responsible for this. He had to find a sliding table-type device that would have enough travel and also be strong enough to withstand the loads placed on it. He also designed the fixture to hold the cartridge on the table. ...."

In Sample 1, the student was unable to describe the delineation of duties or the way in which his group worked together. In Sample 2, the duties and assignments are clear. Each student's paragraph was analyzed to determine which of the performance criteria the student was able to demonstrate. The results are shown in Figure 1.

Figure 1 illustrates that students had difficulty providing evidence of teaming skills. Approximately 65% of the students were able to demonstrate that they shared roles and responsibilities. Only 23% of the students were able to provide evidence that their team was able to discern feasible solutions.

Figure 1: Percent of Students Demonstrating Criteria in Self-Assessment



INSTRUCTIONAL CHANGES

As a result of students' inability to document their teaming skills, several changes were made in the course delivery in the winter quarter of 1999-2000:

- Students participated in team building activities. The team roles of leader, recorder, timer, questioner, and encourager as described in Teams in Engineering Education [1] were explained to students, and they practiced these roles in group exercises.
- Students were given instruction on how to use a Gantt chart to schedule project activities and each group was required to prepare a Gantt chart.
- Students were given instruction on group decision making and the use of either a Pugh selection chart or a decision matrix as an aid in decision making.
- Students prepared detail peer evaluations in which they listed all tasks that each member of the group performed.
- During weekly team meetings with the instructor, students were asked about their teaming skills in addition to their progress on their project.

The effects of the instructional changes were monitored in two ways. First, the instructor kept a log of weekly meetings and checked when students were able to describe verbally how they had achieved teaming goals. A sample form is shown in Figure 2. Notice that the team was able to demonstrate all of the teaming criteria, but that they were quite late getting started on the project. The first three weeks, the team spent the time studying the problem and trying to develop a strategy. The advantage of discussing teaming with the students each week is that the instructor can probe the initial student answers until she is satisfied that the students understand their performance.

Figure 2: Sample Instructor Worksheet Indicating Group's Ability to Demonstrate Teaming Skills

Group #4 Oil Filter Lock								
Members: Students X,Y,Z								
	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9
Share responsibilities and duties					X		X	
Take on different roles when applicable				X				
Analyze ideas objectively				X	X	X		
Discern feasible solutions						X		
Develop a strategy for action				X				
Build consensus					X			

The results of the instructor interviews are shown in Figure 3. Students scored higher in the verbal interviews in all categories after receiving instruction in teaming than before receiving instruction. Notice that 100% of the student groups were able to demonstrate that they could share responsibilities and duties, take on different roles when applicable, and develop a strategy for action. Students still had difficulty demonstrating that they analyzed ideas objectively, discerned feasible solutions, and describing how they arrived at a consensus. The students" inability to describe how they arrived at a consensus may be due to the fact that the project was not turned in until the tenth week and students were not interviewed that week. Some groups did not reach a consensus until the day before the project was due.

The second way in which the instructional changes were assessed was requiring students to submit copies of their work to the Rose Electronic Portfolio System. These submissions were evaluated by the instructor and independent raters. The results of the instructor's evaluations are shown in Figure 4. Notice that the students were not able to demonstrate that they had shared responsibilities and duties and taken on different roles in the electronic submission even though they could discuss this quite convincingly with the instructor. The percentage displaying the ability in the electronic submissions was less than before instruction. This discrepancy may be caused by the students' lack of understanding of what constitutes evidence. Many students submitted their final design report as evidence that they shared responsibilities and duties; however, a final design report does not usually state which team member performed which roles.

Figure 3: Percent Demonstrating Criteria in Interview

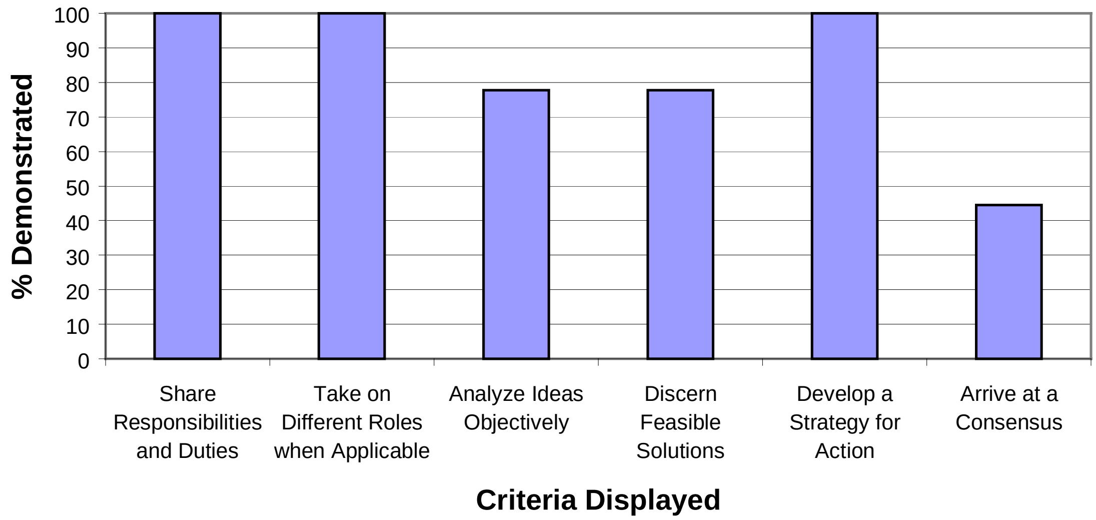
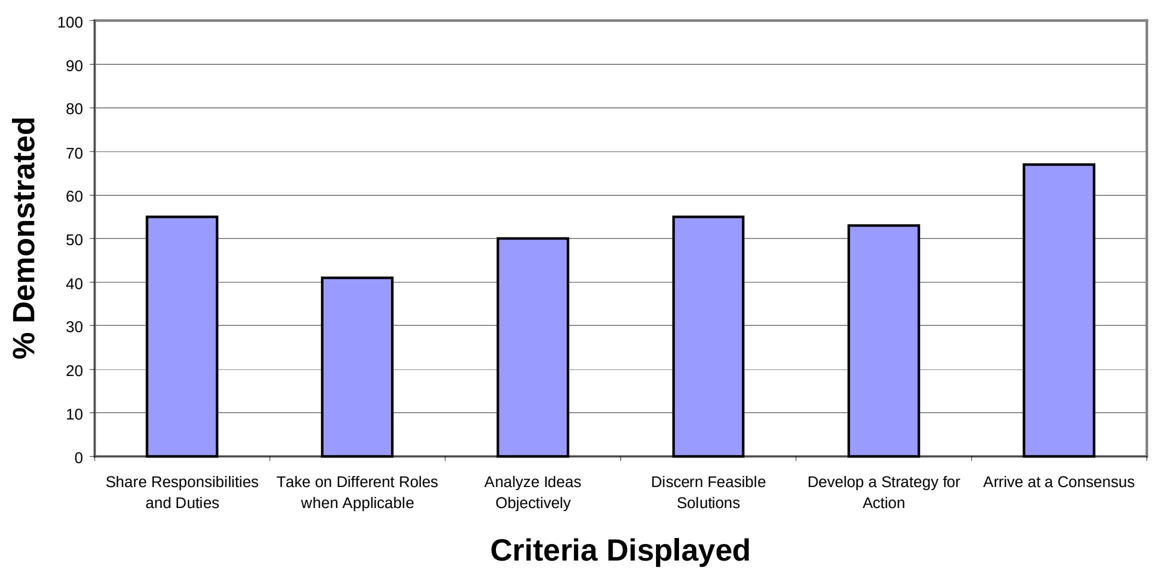


Figure 4: % Demonstrating with Electronic Portfolio



Group progress reports or team peer evaluations are more suitable submissions. The discrepancy between what students could explain verbally and what they could demonstrate in the electronic portfolio may also be caused by the students' lack of confidence. Novices often do not realize what they know. [2] The only category in which students performed better in the electronic submissions was in the "arrived at a consensus" category. This may be due to the fact that the electronic submissions were due during finals week after the written report was submitted. This gave students a chance to think about how they had obtained a consensus as a group.

PEER EVALUATIONS

Students were asked to submit peer evaluations twice during the quarter. The students were asked to indicate what tasks they and each group member have performed. They were also asked to indicate strengths and weaknesses for each group member. Finally, they were asked how they would distribute a bonus to the group based on performance. The first evaluation was submitted at mid-term and the results were distributed anonymously to the group members. A second evaluation was submitted at the end of the project. A sample form is shown in Figure 5. Examination of the form indicates that each of the group members had well-defined roles. It also indicates that Student C wanted to be told what to do and served as a helper for the other two group members. Student C felt that he did not contribute as much to the group as the other two members. Examination of Student B's and A's evaluation forms confirmed that this was the case. Interestingly, Student B and A were not as harsh in their evaluation of Student C. They appreciated his help and felt that he was a contributing group member.

Figure 5: Sample Team Member Evaluation

Headings	Tasks Performed	Strengths	Area for Improvement	Share of Bonus ($1000)
Self-evaluation Your Name: Student C Your Box Number:_______	**1. Researched Hard Drive Problem 2. Helped on Decision Matrix 3. Assisted with Testing**	**1. Knowledge of Computers 2. 3. 4.**	**1. Motivation 2. Screwdriver usage 3. Initiative 4. Paper writing skills 5. Presentation skills 6. Misses meetings**	**200** Additional Comments:
Name of Team Member 1: __Student B	**1. Kept time table 2. Wrote progress reports 3. Researched other designs 4. Performed design 5. Got materials**	**1. buying well insulated screwdrivers 2. communicating with people 3. getting things done**	**1. picking group members 2. immune system (sick a lot) 3. tell people what to do**	**400** Additional Comments:
Name of Team Member 2: Student A	**1. Found ASTM testing standard 2. Ran tests 3. Analyzed data 4. Built prototypes**	**1. Wasn't the one stupid enough to touch 2 live wires with a screwdriver 2. takes charge 3. gets things done 4. keeps project on time**	**1. unplugging proper equipment 2. works ahead of time 3. 4. 5.**	400 Additional Comments:

RUBRICS

The students' confusion about what constitutes evidence led us to articulate what we were looking for in an electronic submission. The Commission on Student Outcomes developed rubrics for each of the teaming goals. The teaming goals and their associated rubrics are shown in Table 1. The "share responsibilities and duties" rubric clarifies that the rater expects to see the role of each team member and an explanation of how this assignment of roles facilitated the project completion. The "take on different roles when applicable" rubric indicates that a student must have done more than perform just one role in a project. It is not acceptable for a student to make drawings and perform no other task in the group. The rubrics help distinguish between sharing responsibilities and duties and taking on different roles. It is possible that a group might demonstrate sharing responsibilities and duties by assigning one role to each group member, *i..e*, project manager, drafter, designer, manufacturer. This would meet the requirement for sharing responsibilities but might not meet the requirement for taking on different roles.

Table 1: Rubrics for Teaming Performance Criteria

Criterion 1: Share responsibilities and duties **Description:** The student should describe the roles of each team member and indicate how sharing responsibilities facilitates project completion. **Example:** In a team member evaluation, a student might list the tasks performed by each member of the group. **Not Acceptable:** To list only the student's own responsibilities
Criterion 2: Take on different roles when applicable. **Description:** The student should describe each role he/she played in the team. **Example:** A student might be team leader for one meeting, recorder for another meeting, responsible for generating AutoCad drawings, and checking design calculations. **Not Acceptable:** To list only one role performed.
Criterion 3: Analyze ideas objectively. **Description:** The student should indicate which ideas were considered and how the ideas were evaluated. **Example:** A student might list pros and cons for multiple ideas. **Not Acceptable:** A list of ideas without analysis
Criterion 4: Discern feasible solutions. **Description:** The student should discuss the outcome of the analysis of ideas and provide a brief justification. **Example:** A student could justify the group's decision based on economic factors.
Criterion 5: Develop a strategy for action. **Description:** The student should identify the tasks necessary for successful completion of the group project. **Example:** A student might use a Gantt chart to prepare a timetable for completion.
Criterion 6: Build consensus. **Description:** The student should articulate the process the group used for determining their final solution. **Example:** The student might submit minutes from the group meeting where the final solution was selected. **Not acceptable:** Submission of the final report without explanation of the process by which consensus was reached.

CONCLUSIONS

Students do not necessarily learn to be effective team members by participating in teams.

Students with team experience had difficulty demonstrating the ability to meet teaming performance criteria. Instruction in team building, project management, and team management enabled students to improve their acquisition of teaming skills in verbal interviews. Students were not able to demonstrate their improvement of teaming skills in a consistent manner in portfolio submissions. Teaming rubrics were developed to make the performance criteria more explicit.

BIBLIOGRAPHY

[1] Bellamy, L., *et. al.* Teams in Engineering Education, AReport Submitted on Work Completed Under Sponsorship of the National Science Foundation, Grant Number USE 9156176, Tempe, Arizona, 1994.

[2] Process Education Teaching Institute Handbook, Pacific Crest, Corvalis, 1999.

BIOGRAPHICAL INFORMATION

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