Evaluation of Cooperative Competition as an Educational Strategy in Project-Oriented Technology Education

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Abstract

Competitions can create an effective learning environment by engaging students in active and cooperative learning. And while competition and cooperation are usually considered by educational researchers to be opposites, they can be used in conjunction to support learning. This study discusses the results of teaching upper-division and graduate-level technology courses that include a competitive project as a major part of the class. In this setting, students design and construct electronics projects, with ample opportunity for creative expression. The project goal is clearly defined, but the solution is not strongly constrained, and students work in teams to find it. In turn, the cooperation among team members and the competition between teams, and often, the cooperation between teams as well, all serve to motivate the students and enhance various aspects of learning. This approach was used with two different groups of technology students at two universities. Student response was evaluated using qualitative evaluation techniques and analyzed for trends and student impact. We also report on how to design a competition-based course to meet educational needs.

Introduction

Higher-education institutions seek to create effective learning environments. At the college or university, level, students are commonly educated through cooperative or active learning. More than thirty years of qualitative and quantitative research shows that active learning is one of the most powerful methods for influencing higher order thinking skills[1]. While competition can be viewed as one of the methods for achieving active learning, many proponents of the active learning theory argue that it does not fit with active learning. Likewise, some proponents of cooperative learning, such as Johnson and Johnson[2], disapprove of competition, while others, such as Slavin[3], support inter-team competition. Because competition is often viewed as being the opposite of cooperation, educators tend to refrain from using competition as an active learning method, with the exception of many engineering technology educators, who use competition in combination with other active learning methods. Research in primary education supports cooperative learning over competition learning, as competition learning is almost always assumed to be individualized competition. Competition learning in higher education, on the other hand, is not necessarily individualized, but rather can be applied as cooperative competition[4], in which the students compete in groups.

The main focus of this study is to determine whether competition, combined with an element of cooperation, can be an effective active learning method in engineering technology education. The following questions were considered:

- Does competition in class lead to effective learning?
- Does competition hinder cooperation between students?
- Does competition in class increase student motivation to learn?
    - Positive "I want to win"
    - Negative "I don't want to be publicly embarrassed in the competition"
- Does competition in class make students more independent as learners?
- Can we compare and contrast the effects of competition in learning between multiple class situations?

In order to answer these questions, two competitions were conducted at the same time at two different universities, using upper-division and graduate-level technology students. The results were measured through the combination of a student survey and participation in a discussion group at the conclusion of the competition.

Because of previous work with competitions, it was expected that:

- Students would learn at a deeper level because of the competition.
- Students would cooperate within their teams.
- Competition would increase the students' motivation to learn.
- Students would conduct a significant amount of research outside of class.
- Competition would have similar effects, regardless of the university or professor.

This study confirms previous cooperative learning research and reinforces the viability of the competition method in engineering technology education.

Method

This study was conducted in an upper-division course and a graduate-level technology course, each of which included a competitive project as a major part of the class. One class consisted of 15 students and the other class consisted originally of 8 students but only 6 completed the tasks. In each class, the students were assigned into groups of two or three. The authors are aware that teams of two are a special case of teaming but the class size made this necessary. Team assignments were chosen in an attempt to balance the abilities of the teams for a fair competition. The groups then competed against each other by building their group projects over the course of a semester. One class' project was self determined using an embedded computer system, the other class designed miniature mobile robots. In each case students had considerable latitude in design but were supplied with a common development platform. At the conclusion of the competition, the students were given a survey, in which a neutral answer was a 4 and an extreme answer was a 1 or 7 (see Appendix A). The surveys were administered anonymously and students were informed that they were not related to class grading. The students were also invited to participate in discussion groups and to respond to a series of open-ended questions about the competition (see Appendix B).

Results

Table 1 illustrates the results of the numerical part of the survey. Fifteen students in class 1 and 5 students in class 2 completed the survey. The mean and standard deviation were calculated for both classes individually, together, and together without the outlying answers.

	Class 1		Class 2		Overall		Overall w/o outliers	
Question	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
1	5.27	1.44	5.20	2.17	5.25	1.59	5.67	0.97
2	4.53	1.25	5.00	1.22	4.65	1.23	4.65	1.23
3	4.00	0.76	5.40	1.34	4.35	1.09	4.35	1.09
4	4.40	1.45	5.60	1.14	4.70	1.45	4.70	1.45
5	4.47	0.74	4.40	1.52	4.45	0.94	4.45	0.94
6	4.13	1.19	5.80	0.84	4.55	1.32	4.55	1.32
7	5.00	1.41	6.00	0.71	5.25	1.33	5.61	0.78
8	4.53	1.55	5.20	2.17	4.70	1.69	5.29	0.92
9	3.40	1.80	4.60	1.52	3.70	1.78	3.79	1.78
10	3.93	0.88	4.80	1.48	4.15	1.09	4.15	1.09
11	4.53	1.13	3.60	1.82	4.30	1.34	4.61	0.98
12	4.73	0.88	5.80	1.30	5.00	1.08	5.00	1.08

Table 1. The numerical results of questions 1–12 from the survey given

The results of the survey indicate all neutral-to-positive responses from the students on aspects of competition learning. The most significant mean of the survey was about cooperative learning (Q1), showing that most students prefer to work in groups rather than individually. The related question 11 was also positive, although not as markedly. The next significant mean of the survey indicated that the most support on the competition project comes from the professor or TA (Q7) followed by support from other students in the group (Q8). The instructor(s) are obviously viewed as an expert resource; nevertheless, other responses indicate that students still take significant responsibility for finding their own information. Question 9, which had the lowest mean, indicated that some support does come from other teams, but not as much as from the professor, TA, or group. This result also had the highest overall standard deviation, indicating that some teams received a great deal of support from other groups, while other groups received none at all. This is discussed further later. Question 12 investigated the opinion of the students on whether it was appropriate for groups that are competing against each other to share information and help each other. The students responded that they thought it was actually good for the groups to work with each other, even though only a small portion of support actually came from the other groups. Other interesting but not as strongly supported results indicate that most students believe that a project-based class with a competition promotes more long-term learning than classroom learning does (Q6), and that students reported spending a moderate amount of time outside of class for research (Q5). The remainder of the results was not considered significant enough except to say that the students were slightly in favor of competition learning.
Figure 1 illustrates the results from question 13 of the survey, regarding critical decisions made by the students in their groups. Critical decisions were decisions that were considered too difficult to change later on in the competition. Part Selection ranked as the most common critical decision made, followed by Project Selection.

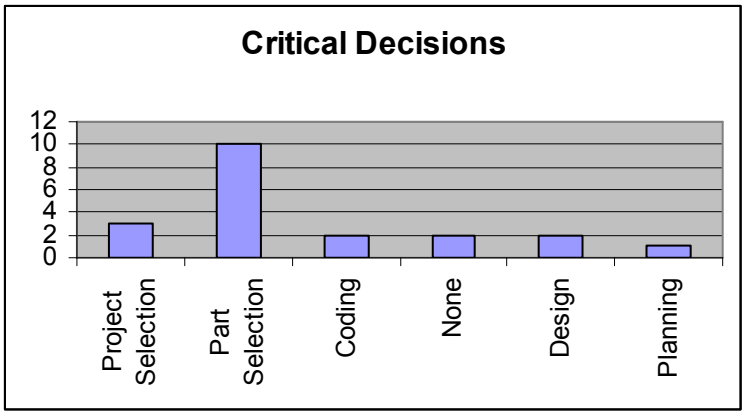

Figure 1. The number of decisions that were considered critical regarding a certain subject

Figure 2 illustrates the individual students' opinions on how equally the work was shared among the members of the group. While most students thought there was an equal sharing of work in the group, some students thought the workload wasn't shared equally. It was also evident that the students in one group did not get along with each other. This Figure corresponds to Question 14.

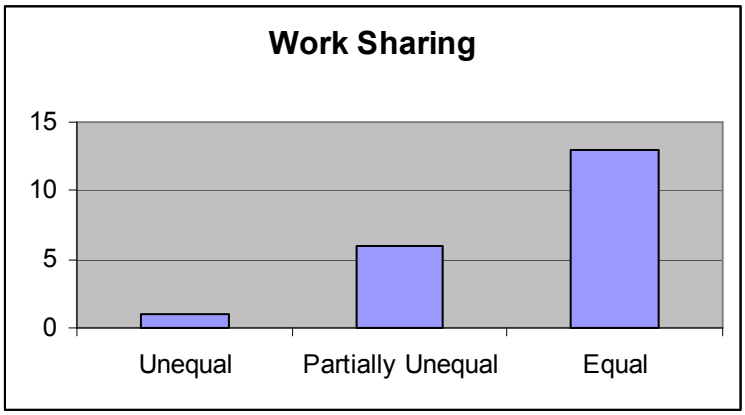

Figure 2. The students' view on the proportion of work in the group.

Figure 3 illustrates some of the surprises experienced by the students working on the competition project. A number of students were surprised with the amount of time required for coding and design work, while others found that they weren't surprised by the class requirements. This Figure corresponds to Question 15.

Analysis of the discussion group's answers provided further insight into the cooperative nature of the competition and helped to clarify some of the answers to the survey questions. One result from the survey that was unclear was the response to question 9. The discussion group responses indicated that the large standard deviation was probably time-related: Some students in one of the classes felt there was a cooperative attitude earlier in the competition, but that it diminished later. In the other class, cooperation was less evident initially but grew substantially later. Both classes noted significant inter-team cooperation at some stage of the project. Most of the students said that they would rather have the competition, as opposed to not having it and just doing

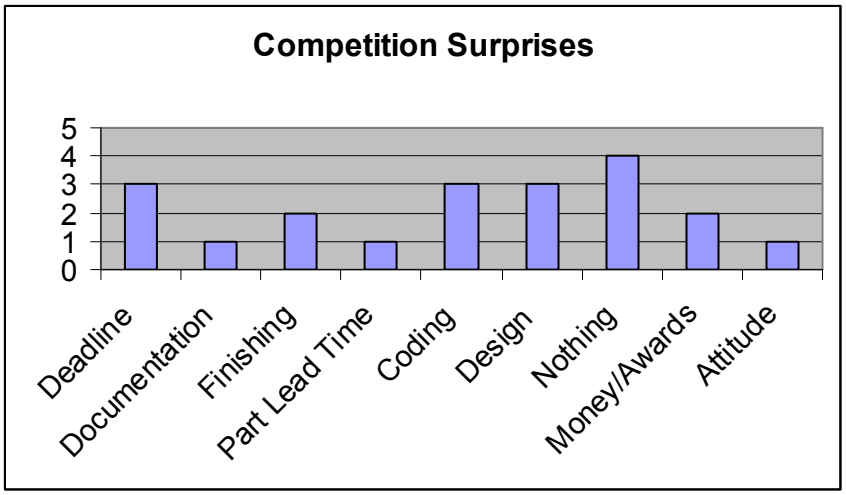

Figure 3. Competition items that surprised the students.

projects. They indicated that the competitive element caused them to extend themselves technically. They also indicated that they appreciated how groups with stronger programming skills helped the other groups. Some standard cooperative results were also noted, such as when students reported that their team-mates added a different perspective to the project and more insight into achieving the goal.

In the graduate project class, some interesting dynamics were observed. Initially, the teams were keen to develop the best robot and even asked if it was acceptable to push competitors' robots off the track or otherwise interfere with them. In general, the interaction between teams was competitive and, in some cases, aggressive. As time passed and the teams realized how complex a task it is to simply get a robot to complete a series of tasks, balancing the needs of all the subsystems, they became much less concerned about how well the other teams were doing. In the last couple of weeks of the semester, the teams became extremely concerned about getting their robots to perform at a minimal level, and therefore became much more cooperative with the other teams. They traded ideas, insights, and even sections of computer code. In fact, although they knew that the grading was going to be competitive, they were extremely cooperative. At the final competition, each of the three teams showed strength in different areas. While competitive points were awarded, all of the students seemed excited and pleased to see every robot running. They had developed a sense of camaraderie in the face of adversity. It is hard to say whether this togetherness was enhanced because there were so few students, or because the task was difficult enough to create a climate of mutual support.
In a revealing case, one of the teams was reduced to a single student because his teammate dropped out shortly before Thanksgiving. Several of the students from other teams made a point of mentioning in the discussions how hard he had worked and how they felt he deserved extra consideration since he was working alone. Two students even said that he had worked harder than any other single individual and should be rewarded accordingly, despite the fact that his robot had the worst performance.

It is important to note that the students did dislike certain aspects of the competition. Some felt that it should have been better organized beforehand by the professor. They also needed more help from the TA during the lab time. When the deadline approached and some teams weren't

quite finished, the students felt incompetent because they did not know enough and were not adequately prepared to contribute to the competition. Coding problems and failures in part testing were the two biggest contributors to frustration. When one team finished their project and stopped assisting other teams, those who were left behind reported feeling less motivated. This is one of the factors that may have led to the high standard deviation noted on survey question 9. The professor also noticed this decline in motivation. The students suggested that through better preparation, they would do better.

Lessons Learned

This study has shown that both cooperation and competition can play a role in active learning. We found very little evidence that competitiveness hindered learning, except in the case of declining cooperativeness when some teams finished earlier than others. In general, the positive effects of cooperation were noted between individuals and between teams, although the cooperation within teams was notably higher. The cooperation among team members and the competition between teams each served to motivate and enhance different aspects of learning. Competition as an active learning method requires much time and preparation beforehand, and is more appropriate when the professor is an expert on the subject matter. The competition also has to be structured to help ensure its success. Some recommendations for competition include:

- Group the students into teams that are balanced in ability so that the competition is fair.
- Make sure that the objective is well matched to the engineering technology concept being taught.
- Maintain and encourage contact with the students.
- Encourage cooperation among the students.
- Give prompt feedback to the students.
- Emphasize planning and time management.
- Maintain an appropriate balance between classroom and laboratory time so that the students are able to work productively in the laboratory.
- Encourage students to respect and benefit from each others diverse viewpoints
- Have clear goals and grading standards for the class while allowing considerable freedom for students to express their creativity.

With these principles in mind, engineering technology educators can use competition to create an effective learning environment and engage their students in active cooperative learning.

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Appendix A: Survey

1. Do you think you could have done better individually on this project, or did working in a group work out better?

Best individually			About the same			Best as a team
1____	2____	3____	4___	5___	6___	7___

2. How was the communication within your group?

A hindrance			OK			Excellent
1____	2____	3____	4___	5___	6___	7___

3. Was class time or project/competition time better as an educational experience?

Class better			Both same			Project better
1____	2____	3____	4___	5___	6___	7___

4. What was the relationship between team members?

Hostile			Neutral			Very Positive
1____	2____	3____	4___	5___	6___	7___

5. How much independent research did you do to find materials for this project that were not provided in the class materials?

None			Some			Very much
1____	2____	3____	4___	5___	6___	7___

6. What, in your opinion, is the long-term effect of project/competition vs. classroom/homework learning?

Class more effective			Same		Project/Competition more effective	
1____	2____	3____	4___	5___	6___	7___

7. How much support did you feel you received from the professor/TA?

None			Some			Very much
1____	2____	3____	4___	5___	6___	7___

8. How much support did you feel you received from your team members?

None			Some			Very much
1____	2____	3____	4___	5___	6___	7___

9. How much support did you feel you received from other teams?

None			Some			Very much
1____	2____	3____	4___	5___	6___	7___

10. What is your opinion of competitions as part of the classroom environment?

Hinder learning			Just another teaching method			Help learning
1____	2____	3____	4___	5___	6___	7___

11. Do you prefer to work in groups or by yourself?

Definitely alone			Both same			Definitely in a team
1____	2____	3____	4___	5___	6___	7___

12. How do you feel about groups working with each other (cooperating)?

Between-group coop is bad			About same			Coop is good
1____	2____	3____	4___	5___	6___	7___

13. What decisions did you make in the competition that were considered critical?

14. Do you feel that your group had a star/slacker that did significantly more/less than their share of the work? How did you feel about this? What did you do?

15. What about the competition surprised you the most?

Appendix B: Free Response Questions

Likes:

1. Do you think certain partners added a different perspective to the project and gave you more insight into achieving the goal?

2. How would you rate cooperation with the other teams? Did they share with you information that they learned? Did you help them out as well?

3. How do you think the competition followed/collaborated with the class?

4. Did the competition get you to think about the class in a different way?

5. How did you like the team selection at the beginning?

6. Did having the competition as part of the class increase or decrease your desire to learn?

7. What aspect of the competition did you like the most?

8. At what time in the semester did you feel most engaged with what was happening in your group?

9. What did your teammates/professor do to make the competition more helpful?

Dislikes:

10. What did you feel the professor did wrong in this competition or could have been done better?

11. What aspect of the competition did you like the least?

12. At what time in the semester did you feel most distanced from what was happening in your group?

13. What did your teammates/professor do to make the competition less helpful?

Improvements:

14. What could the professor have done to make this experience better for you?

15. What would make the competition better?