Peer Evaluation within a Team Design Project

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ABSTRACT *- Working in a global economy requires graduates of engineering and technology programs to perform effectively within group or team environments. Within academic programs of study, group projects are often utilized to facilitate and promote team dynamics and situations. If employed successfully, a group project can draw on the talents of all students in a manner that provides results and promotes a positive understanding of team concepts. If employed haphazardly, group projects can lead to unbalanced work loads, social loafing, and a dislike of such projects by both students and faculty. This paper details a team design project within an engineering design graphics course. Highlighted is a peer assessment instrument utilized to enhance collaborative efforts.*

I. INTRODUCTION

As the present global economy increases competition among original equipment manufactures, enterprises must find ways to decrease time-to-market of new products while at the same time increasing quality and decreasing costs. One of the deployed solutions to this complex problem is the implementation of principles of concurrent engineering. Concurrent engineering was established to help meet the quality demands of stages within the lifecycle of a product. According to Bedworth, Henderson, & Wolfe, "Concurrent engineering has as its purpose to detail the design while simultaneously developing production capability, field-support capability, and quality" [1]. It involves the concurrent arrangement of design functions into one design team consisting of individuals that represent the life of a product.

Since collaborative design and concurrent engineering technologies and philosophies are increasingly becoming important for competition within global markets, designers and engineers must learn to work effectively within multileveled and diverse design teams. Due to this, team design problems should also be stressed within engineering, engineering technology, and industrial technology programs.

The importance of team design problems is highlighted by engineering and technology accreditation organizations. Current American Board for Engineering and Technology (ABET) and National Association for Industrial Technology (NAIT) accreditation standards stress the importance of teamwork, problem solving, and design [2,3]. Specifically, the engineering accreditation commission of ABET requires that graduates attain 1) "an ability to function on multi-disciplinary teams", and 2) "an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice". Additionally, the integration of concurrent engineering strategies, design processes, and collaborative design is important and relevant in technology and engineering curriculum models [4,5].

II. PURPOSE

With the potential for an increase in team design problems in engineering and technology comes the need to find evaluation methodologies for individuals within design groups. This paper focuses on the deployment of a peer evaluation instrument to evaluate individuals within team design projects.

III. LITERATURE REVIEW

In addition to the requirements for team exercises by accrediting agencies such as ABET and NAIT, there are many other advantages to having team projects within engineering and technology programs. Employers are demanding that students have sound "soft" skills such as writing, communicating, and working effectively within group environments [6]. Additionally, well planned group projects allow students to learn thinking strategies from their interactions with peers which in turn increases student involvement and ownership. [7,8]

There are many potential disadvantages to assigning group projects. Arguably the biggest concern is social loafing [9,10,11]. Social loafing occurs when students attempt to do as little group work as possible in the hope that their groups will be successful without their cooperation. Social loafing is a major cause for team dysfunction and a hindrance to student learning and achievement [12]

To avoid social loafing, teams should be organized to allow for equal participation from all members. This organization requires individual responsibility while promoting interdependence among group members. According to Johnson and Johnson, five essential elements are necessary to allow for true team efforts: (a) positive interdependence, (b) individual accountability, (c) face-to-face interaction, (d) social skills, and (e) group processing. [13]

While common educational methodologies either require students to compete for grades, or to work alone to accomplish an educational goal, successful teams should have a positive interdependence, where the successful outcome of one group member is dependent upon the successful outcome of each group member. In addition, well functioning groups require every team member to be held individually accountable for handling their share of the load. Through design or through neglect, these two elements of cooperative learning are not incorporated into most team design projects. While neglecting these two elements can still lead to successful group outcomes, there is no assurance that social loafing will not occur or that all members of the team will benefit equally.

One of the downfalls of team projects is inadequately evaluated group work. There are multiple ways to evaluate a team project. Turning in individual reports has potential, but it can be impractical and doesn't promote teamwork.[14] Some instructors just give the same grade to all team members. While this method is easy for the instructor, it is considered unfair by most students and promotes social loafing within teams.[15,16,17] One method that can promote social skills and teamwork is assigning individual roles to students within a group. But, this approach does not provide a good assessment tool for individual skills.

One evaluation method that has been used successfully and has the potential for the development of teaming skills while decreasing the likely hood of social loafing is the utilization of peer evaluations.[18,19] Team members are the best evaluators of their teammates.[20] They can closely observe the work and behaviors of their team members while remaining in a position to provide objective summative evaluations. Since levels of interdependence must exist between group members, it is critical that all

teammates function well within their respective groups. Additionally, Peer ratings are positively correlated with other rating sources such as supervisor, self-rating, and subordinate rating.

According to Millis and Cottell, an important component of peer evaluations in team design projects is the adjustment of individual student grades based on peer feedback.[21] This technique for implementing peer evaluations allows a project to be scored based on the group outcome while still providing individual grades for student participation. Students derive from the project attributes associated with the completion of a team project with the knowledge that their individual efforts were also rewarded.

IV. TEAM DESIGN PROJECT

The team design project highlighted in this paper occurred within a freshman level engineering design graphics course (IET 154) in the Department of Engineering and Technology at Central Michigan University. This course is required for students in mechanical engineering, mechanical engineering technology, manufacturing engineering technology, and industrial technology. This course has two goals: 1) to teach students the fundamentals of engineering design, and 2) to teach students how to utilize graphics within engineering design processes.

A team design project is a significant component of this course. The project assigned during the timeframe of this paper was a basketball goal system (Figure 1). Students within their individual lab sections were organized into teams of three or four students. Each team followed a formal design process which includes the following steps:

1. Customer Needs
2. Product Target Specifications
3. Design Concept Generation
4. Design Selection
5. Final Product Specifications
6. Detail Design

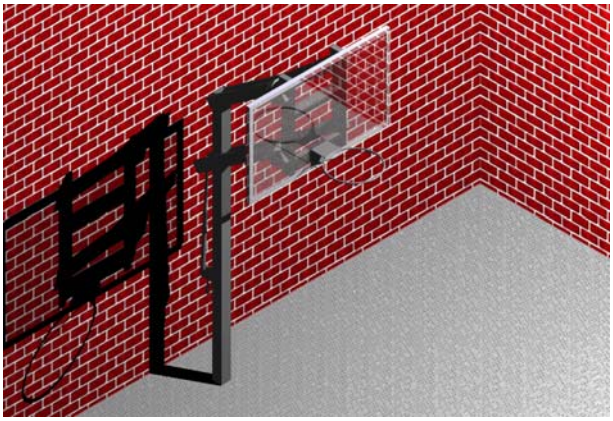

Figure 1 – Basketball Goal Design Project

Team development and organization were important considerations within each design project. Teams were required to be self-administrated and managed. When problems arose within a team, such as social loafing, the team (not the instructor) was responsible for finding and implementing a solution. When teams were formed and the design problem presented, the instructor provided a list of required tasks along with approximate times necessary to complete each task. From this list, each team assigned tasks for specific members to perform. Additionally, each team developed a group mission statement and a set of team rules and polices. Examples of issues addressed within a set of rules include: (a) meeting attendance, (b) communication methodologies, (c) personal problem solving, and (d) member task requirements.

V. PEER EVALUATION INSTRUMENT

The peer evaluation instrument described in this paper was select for its ability to assign individual grades to a team design project while still allowing for a valid assessment of the group project as a whole.

The evaluation instrument was divided into two sections. The first section measured each team member in the following work related categories (see attached evaluation sheet):

a) Quality of Work – Value and quality of contributions, suggests, opinions, ideas.
b) Quantity of Participation – Sharing of responsibility, willingness to do his/her share of the work, prepared for meetings.
c) Timeliness – Attendance at meetings, classes and work sessions. Met deadlines, had work finished and ready on time.
d) Level of Work – Final work was professional and ready to be used.

Total Points					
Name	1	2	3	4	Ratio
Mike	16	16	15	16	63/64 = 0.98
John	16	18	18	16	68/64 = 1.06
Amber	14	16	15	16	61/64 = 0.95
Sue	14	16	16	15	61/64 = 0.95

Table 1 – Work Categories

A score for each member was assigned for each of the categories with a value of four being average, or the expected score, for each student. These four category values for a member as assigned by a teammate were totaled to provide a score. This score was recorded in a spreadsheet table (see Table 1). As an example, for groups of four, the expected score for each member was 16 (4 x 4 = 16) while the maximum score possible was 20 (4 x 5 = 20). Likewise, for a group of three, the expected score is 12 (3 x 4 = 12) while the maximum possible score was 15 (3 x 5 = 15). Note that team members also evaluate themselves. As shown in Table 1, Mike received a total of 16, 16, 15, and 16 points from his teammates. These points came from summing teammate assigned scores off the evaluation instrument. The ratio of earned points to expected points was included in the final column of the table (63 points divided by 64 points possible = 0.98).

Contribution %						
Name	1	2	3	4	Total	%
Mike	0.23	0.25	0.24	0.25	0.97	95
John	0.3	0.28	0.28	0.25	1.11	117.6
Amber	0.23	0.24	0.24	0.25	0.96	93.6
Sue	0.24	0.23	0.24	0.25	0.95	90.2
	1	1	1	1		

Table 2 – Contribution Percentage

The second section of the peer evaluation instrument measured student contribution to the group project. When a student evaluates his team, his or her total must equal 100%. As an example, in table 2, student number one (Mike) provided contribution percentage points of 0.23, 0.30, 0.23, and 0.24 for the members of his team (he gave himself a 23 percent contribution). His total equals 1.00 or 100%. Mike in turn received contribution points from his team of 0.23, 0.25, 0.24, and 0.25. This gives him a total summed contribution of 0.97. Notice in table 2 how a student's total contribution could actually be greater than 1.00. This allows a student who contributed more when compared to the remainder of his or her group to actually receive a final assigned grade that is higher than the evaluated group grade.

The nature of this approach to assigning a grade for a team project is designed around a student that did an average job in his or her work categories (four points averaged in each area) while contributing equally with every member in his or her group (a 100% contribution score). Such an average student would receive his or her evaluated project grade without any modification.

The work categories table and the contribution table are used to modify an assigned grade for each individual

student on a team. If a student's work category scores are lower than average (below four points) then his or her final grade on the project will decrease. If a student's contribution is greater than average, then his or her final grade will increase. For contribution, if a student's contribution was greater than average, then there is potential for an individual's final assigned score to be actually higher than the project score.

The student's earned grade is the product of the work category ratio, contribution ratio, and project grade. In tables one and two, let's assume that the project grade was scored an 85 by the instructor. Sue had a 0.95 ratio on her work category and a contribution ratio of 0.95. Her assigned grade would be

0.95 X 0.95 X 85 = 76.71

This grade might appear significantly lower than the scored project grade of 85, but upon closer evaluation it becomes evident that Sue's grade was appropriate. She had below average evaluations on her work categories while contributing less than average within her group. It is important to remember that the peer evaluation instrument is designed around a student that performs with an average score of four on the work categories. Anything less than average is considered sub par. On the other hand, Mark had excellent peer evaluations and his final grade reflected this:

1.06 X 1.11 X 85 = 100.24

VI. METHODLOGY

During the Fall 2004 semester, IET 154's group project was conducted without the use of a peer evaluation instrument (N = 27). During the Spring 2005 semester the identical design project was implemented, but with the use of the previously described peer evaluation instrument (N = 25). Students during both semesters also individually completed a questionnaire that was designed to measure their perceived effectiveness of their design groups. A Likert scale was utilized to measure responses (1 Strongly Agree, 2 Agree, 3 Neutral, 4 Disagree, and 5 Strongly Disagree) to the following statements:

1. My group functioned well together.
2. All members of my group did their fair share of the assigned group project.
3. I enjoyed the group project.
4. The group project was a valuable component of the course.
5. If I had a choice of doing a group activity or doing extra individual assignments, I would chose to do extra individual assignments.

VII. FINDINGS

A two-sample t-Test was used to determine any statistical significance difference between each semester on each question.

Team Functioned Well Together	*No Peer Evaluation*	*Peer Evaluation*
Mean	2.296	1.560
Variance	0.986	0.423
Observations	27	25
Pooled Variance	0.716	
Hypothesized Mean Diff	0.000	
df	50.000	
t Stat	3.136	
P(T<=t) two-tail	0.003	
t Critical two-tail	2.009	

Table 3 – Question One

There was a significant difference between the two semesters on question one. Teams that utilized a peer evaluation instrument (M = 1.560, SD = 0.423) functioned better together than teams that did not utilize a peer evaluation instrument (M = 2.296, SD = 0.986).

With question two, there was no indication that incidences of social loafing were reduced when a peer evaluation was utilized. All teammates on teams that

did not utilize a peer evaluation (M = 2.667, SD = 2.000) performed their fair share of the group project when compared to individuals on teams that utilized a peer evaluation (M = 2.160, SD = 1.057).

All members of my group did their fair share	*No Peer Evaluation*	*Peer Evaluation*
Mean	2.667	2.160
Variance	2.000	1.057
Observations	27	25
Pooled Variance	1.547	
Hypothesized Mean Diff	0.000	
df	50.000	
t Stat	1.468	
P(T<=t) two-tail	0.148	
t Critical two-tail	2.009	

Table 4 – Question Two

I enjoyed the group project	*No Peer Evaluation*	*Peer Evaluation*
Mean	2.556	1.760
Variance	1.410	0.273
Observations	27.000	25.000
Pooled Variance	0.865	
Hypothesized Mean Diff	0.000	
df	50.000	
t Stat	3.083	
P(T<=t) two-tail	0.003	
t Critical two-tail	2.009	

Table 5 – Question Three

Project was a Valuable Component of Course	*No Peer Evaluation*	*Peer Evaluation*
Mean	2.333	1.760
Variance	1.231	0.440
Observations	27.000	25.000
Pooled Variance	0.851	
Hypothesized Mean Diff	0.000	
df	50.000	
t Stat	2.239	
P(T<=t) two-tail	0.030	
t Critical two-tail	2.009	

Table 6 – Question Four

Differences were found from the responses for questions three and four. Individuals from groups that utilized the peer evaluation within their team project (M = 1.760, SD = 0.273) seemed to enjoy the project more than individuals from groups that did not utilize the evaluation (M = 2.555, SD = 1.410). Individuals that participated in the peer evaluation (M = 1.760, SD = 0.440) also better felt that the group project was a valuable component of the course when compared to the feelings of the individuals that did not participate in the group project (M = 2.333, SD = 1.234).

There was no significant difference for question five. (Table 7)

Individual vs Group Assignment	*No Peer Evaluation*	*Peer Evaluation*
Mean	2.852	3.440
Variance	1.593	1.090
Observations	27.000	25.000
Pooled Variance	1.351	
Hypothesized Mean Diff	0.000	
df	50.000	
t Stat	-1.823	
P(T<=t) two-tail	0.074	
t Critical two-tail	2.009	

Table 7 – Question Five

VIII. CONCLUSIONS

The intent of the study described in this paper was to determine the effectiveness of a peer evaluation on student involvement within a team design project. The results of the study did show that a peer evaluation instrument is a helpful instrument for improving team effectiveness by increasing how well individuals in a group functioned together. The results also indicated that a peer evaluation makes group projects more enjoyable and valuable.

The ability to function well in a team is important in a market driven global economy. Effective teams require all group members to pull together to accomplish the assigned task. Students have to

appreciate the benefits of a well organized team and learn to work effectively in a team environment.

One way of assessing a team is through a peer evaluation. By the end of a group assignment, team members should know their teammates very well. Using this knowledge to assess a team project is a valuable way to promote project effectiveness while also individually evaluating team members.

IX. REFERENCES

1. Bedworth, D., Henderson, M. R., & Wolfe, P. M. (1991). *Computer-integrated design and manufacturing*. p 141. New York: McGraw-Hill.

2. American Board for Engineering and Technology (2004). Criteria for Accrediting Engineering Programs. Downloaded May 12, 2004 from http://www.abet.org.

3. National Association of Industrial Technology (2003). Industrial Technology Accreditation Handbook – 2003. Downloaded May 12, 2004 from http://nait.org.

4. Kumar, V., Kinzel, G., Wei, S., Bengu, G., & Zhou, J. (2000, July). Multi-University design projects. *Journal of Engineering Education.* Downloaded Oct 3, 2005 from http://www.asee.org.

5. Natishan, M. E., Schmidt, L.C., & Mead, P (2000, July) Team performance issues. *Journal of Engineering Education.* Downloaded Oct 3, 2005 from http://www.asee.org.

6. Ravensroft (1997). In support of cooperative learning. *Issues in Accounting Education, 12*(1), 187-190.

7. Zimmerman, B. J. (1990). Selft-regulated learning and academic achievement: An overview. *Educational Psychologist, 25*, 3-18.

8. Petty, P. (1997). Increasing Student Engagement and retention through the Use of Cooperative Groups and Authentic Assessment. (Eric Document Reproduction Service No. ED 411 058).

9. Mello, J. A. (1993). Improving individual member accountability in small group settings. *Journal of management education, 17*(2), 253-259.

10. Beattyt, J., Haas, , R., & Sciglimpaglia, D. (1996). Using peer evaluations to assess individual performances in group class projets. *Journal of Marketing Education*, 17-27.

11. Yamane, D. (1996). Collaboration and its discontents: Steps toward overcoming barriers to successful group projects. *Teaching Sociology, 24*, 378-383.

12. Lewis, P., Aldridge, D., & Swamidas. (1998). Assesing team skills in acquisition on undergraduate project teams. *Journal of Engineering Education, 87*(2). 149-155.

13. Johnson, D. W., Johnson, R. T. & Smith, K A. (1998). *Active Learning Cooperation in the College Classroom*. Edina, MN: Interaction Book Col

14. Levi, D. & Cadiz, D. (1998). Evaluating team work on student projects: the use of behaviorally anchored scales to evaluate student performance.

15. Conway, R. (1993). Peer Assessment of an individual's contribution to a group project. *Assessment and Evaluation in Higher Education, 11*(2), 146-166.

16. Gibbs, G., Habeshaw, T. & Habeshaw, S. (1993). *53 Interesting Ways to Assess Your Students*. Bristol: Technical and Educational Services Ltd.

17. Rotfeld, H. (1998) Hello, bird, I'm learning ornithology. *Marketing Education, 17*, Fall.

18. Longmore, M. A., Dunn, D., & Jarobe, G. R. (1996). Learning by doing: Group projects in research methods classes. *Teaching Sociology, 24*, p. 84-91.

19. Levi, D. & Cadiz, D. (1998). Evaluating team work on student projects: the use of behaviorally anchored scales to evaluate student performance.

20. Metheny, D. L. &Metheny, W (1997). Enriching technical courses with learning teams, *College Teaching, 45*, p. 32-35.

21. Millis, B. J. & Cottell, P. G. (1998). *Cooperative Learning for Higher Education Faculty.* Oryx Press.

Rating form for IET 154 – Engineering Design Graphics

Purpose: This form is used to give you the opportunity to rate the contributions of your self and your fellow team members. The results will be used to determine each individual's performance grade. This page will not be shared with anyone else on the team, so think carefully and be open and honest with your evaluation.

Evaluate each person in your team and rate him/her on a scale of 1 to 5 in each of the categories. Use the following scale to base your rating:

5. Above Average Work
4. Average Work
3. Slightly Below Average Work
2. Significantly Below Average Work
1. Poor or no work in this Category

The contribution percentage column is a measure of your perception of how well each team member contributed to the project. The total of the column must equal 100%. As an example, assuming a four-student team, if you feel that everyone on the team contributed equally, then assign 25 percent to each student (25% x 4 = 100%).

A. Quality of Work – Value and quality of contributions, suggests, opinions, ideas.
B. Quantity of Participation – Sharing of responsibility, willingness to do his/her share of the work, prepared for meetings.
C. Timeliness – Attendance at meetings, classes and work sessions. Met deadlines, had work finished and ready on time.
D. Level of Work – Final work was professional and ready to be used.
E. Contribution to the group (in percent). ***The total for this must add up to 100%.***

Team Member	**A** Quality	**B** Quantity	**C** Timeliness	**D** Level	**E** Contribution %
1. _____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	*_____%
2. _____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	*_____%
3. _____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	*_____%
4. _____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	*_____%
5. _____	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	*_____%

Team:_____ * total for all must = 100%

Give a brief written evaluation of yourself and each team member. Explain problems, conflicts, and confrontations as well as great work, leadership, willing to pick up slack, etc. If you have someone a 1 or 2, please explain why. Use the back if necessary.