

Student Study Group and Design Team Formation Based on Academic Performance Metrics

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Having engineering students work in teams is a challenge for instructors in many courses. Students often self-select members, resulting in unbalanced teams. A performance-based team formation method was implemented in two mechanical engineering courses. Performance on the first exam is used as a surrogate for talent. Students with the highest first exam scores are assigned as group leaders with the rest of the students distributed to balance the teams. Using the first exam grade made group formation relatively easy. Results and feedback from students were surprisingly positive with three-quarters of students preferring the performance balanced team formation method.

Keywords: performance-based teams, team formation, study group, design project, team leader

INTRODUCTION

Student outcome assessment is an important part of undergraduate engineering program accreditation. Engineering design and student teamwork are essential components of the student outcomes that must be assessed and evaluated as an input for continuous improvement of engineering programs (ABET, 2019). In many undergraduate engineering courses, students are assigned a research or design project. These typically include the capstone design course and some other upper-division courses in the program. In large lecture dominated classes, students are either encouraged or required to complete projects in groups consisting of several team members.

Formation of design teams and assigning grades to individual team member is a challenging task for the instructor. Some instructors have had students take personality tests to help place students into balanced groups (Dillon & Cheney, 2009). In one study the design formation methodologies were examined in a multi-section engineering course offering (Dillon & Cheney, 2009). The instructor assigned team members to group projects in half of the sections, and in the other sections, students formed their own teams. The study concluded that “the benefits of using a personality-based approach to team formation by the instructor was that it will ideally increase the creative roles available within design teams, thereby making them well-rounded and more capable of solving complex problems. A disadvantage is that assigning students to teams gives them a point of contention with the instructor since they have no say-so in how their teams are formed and may increase personal conflicts. Allowing students to select their own teams removes this point of contention and may reduce personal conflicts, but also eliminates the benefits gained through the use of

personality types. It is recommended that a hybrid of the team formation by the two methodologies outlined be applied (Dillon & Cheney, 2009).

Other instructors allow student to self-select with no input from the instructor or may use extensive groupings to in areas such as outside work, commitments, personality, motivation, talent and other qualities (Kiassat & Jiang, 2016). In one section of a course students were placed in teams based on their academic ability. Each team was balanced by having a member from each of the “great”, “above average” “average” and “below average” category. The “great” student was designated as the team leader. In another section of the course students formed their own teams and pick their own team leader. The study showed that the students in the sections having teams formed based on the academic ability on the average performed slightly better than those in the section that teams were formed by students (Kiassat & Jiang, 2016).

The goal of grouping is to minimize the potential for dysfunctional teams (Jack, 2007). Teams give students the opportunity to work with others of different backgrounds and talents (Creese & Gupta, 2010). Team makeup often is the primary link to student satisfaction and team success, yet teams often must be formed efficiently and quickly at the start of the semester (Michaelis & Bae., 2019). Online tools have been used to allow students to identify individual preferred projects (Laguetta, 2011). Instructors have used deliberation processes where students identify their preferred team roles (e.g., organizer, creator, worker, or finisher) and preferred projects (Watkins, 2017). Some have identified the students with the most relevant experience and placed them as team leaders (Hertz, et.al., 2019). A new open-source software tool developed called “*gruepr*” for creating optimal student teams (Hertz, et.al., 2019). “The software tool runs on the instructor’s computer using survey data entered by the students into, and then downloaded from, a Google Form. The instructor has considerable flexibility in choosing the content of the survey questions as well as the definition of a quantitatively optimal team.” The importance of a functional team leader is key to have a functional (or dysfunctional) team (Laguetta, 2013). It was concluded that team leadership is significant and does appear to be an impact factor in team performance. Therefore it is necessary to provide guidance to the team leaders. Having a documented peer evaluation is helpful in helping students see the value of leadership and healthy team dynamics (Eschenbach, 1997). Frequent data collection and observation of team member performance requires significant instructor effort, yet in the end saves time by reducing conflicts and the time often required to mediate them (Carson, 2008).

The most common way and simplest way to form teams is to allow students to self-select their teams. There are some advantages for this method. When students select their own team members, they have easier time to schedule meetings. The team members are most likely friends, so it is less likely that they have interpersonal conflicts. A shortcoming is that in most cases, students group based on academic backgrounds and some teams form with weak academic backgrounds making it more difficult for them to complete a meaningful project. Also, when peer evaluation is being used to help assign individual grades to members of a team, the results cannot be trustworthy, since friends very seldom submit a bad evaluation of a team member who has made minimal contribution to the team project. The alternative is for the instructor to assign members to teams.

In the mechanical engineering program at the authors’ institution, several courses are used to provide design experiences for students enrolled in the program. These include a two-semester capstone design, plus several other upper division courses. They are also used to satisfy parts of criterion 3 and criterion 4 of ABET-Engineering Accreditation Commission’s (EAC) eight general criteria requirements for the accreditation of the program (ABET, 2019; Karimi & Manteufel 2020). Criteria (3)-Student Outcome (SO) consists of several components that must be assessed and evaluated. Criterion 4. Continuous Improvement requires that “the program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the continuous improvement of the program.” Criterion 3 of the ABET-EAC general criteria consists of seven student outcomes. Student outcome 2 states “an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.” Engineering design is defined in detail in ABET-EAC’s general criteria document (ABET, 2019). Student outcome 3 states “an ability to communicate effectively with a range of audiences.” Student Outcome 5 states “an

ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.” The general criteria a definition is added for term states “a team consists of more than one person working toward a common goal and should include individuals of diverse backgrounds, skills, or perspectives.” In the new general criteria

In our engineering program, students’ design project reports, presentations, and product produced in the two-course sequence in capstone design are employed for the assessment and evaluation of most of the student outcomes 1 through 7 for the accreditation process. Student work in other upper division courses are also being utilized for the assessment and evaluation of SO1 through SO7.

TEAM FORMATION IMPLEMENTATION

A second course in Thermodynamics (Thermodynamics-II) and a course in Heat transfer are required courses in the curriculum for the BS degree in Mechanical Engineering in our institution (Manteufel & Karimi, 2016). Design projects are included in these courses to provide additional design experience for students and provide supplemental data for the assessment and evaluation SO2, SO3, and SO5 in accreditation processes.

Prior to fall 2018 students were allowed to form their own teams to complete the design projects assigned in Thermodynamics-II and Heat Transfer. We also asked each team member to give an honest evaluation of other team members for their contribution in completing the team projects. In most cases, all team members indicated that every member contributed equally to the final project product. Occasionally interpersonal conflicts developed among team members. In these cases, one or more team members claimed that they have done most of the work on the project with little or no contribution from other members, while the other members claimed that they have contributed equally to the final project. Also, there were big differences in the quality of design project reports submitted by various teams in the course. It was observed that some teams were formed by academically high performing students while all members of some other teams were students that were struggling in the course.

Fall 2018 Team Formation in Thermodynamics-II

In fall 2018 it was decided to experiment with a new approach in forming the teams. In two sections of Thermodynamics-II course offered in fall 2018, it was decided for several reasons that the instructor should play a more direct role in the formation of design teams. The reasons included the followings: One important goal of engineering education is to prepare graduates who can function well in their future jobs. In job situations, individuals seldom select their own teams, but most likely they are assigned to a project by someone else. Also, we wanted to mix the academically high performing students with those who were struggling in the course in the formation of team projects. The goal was that better performing students could help weaker students to learn the course materials and make a more meaningful contribution to the design project.

In fall 2018, performance-based team formation method was implemented in two the Thermodynamics-II course having enrollments of 83 and 44 students, respectively. Three mid-terms and a comprehensive final exam were given in each section. After the second exam a design project was assigned. The total points earned by each student in the first two exams were sorted in spreadsheets for each section. In section 1, the total points of the two exams for students were in a range from 29 to 200 points. Sixteen (16) students scoring total points ranging from 188 to 200 points in two exams were identified as the leaders of design team 1 through 16 for the assigned design project. Each remaining student was asked to select three teams as their first, second, or third choices and submit their selection to the instructor. The instructor first assigned one student whose total points for the first two exams was among the lowest 16 scores in the class to each of the 16 design teams. Then two or three more students were added to each team based on students’ performance in the first two exams. Attempts were made to honor students’ choice on team selection as much as possible and keep the diversity of student performance in the first two exam similar for all 16 design teams. A similar procedure was used to form design teams in section 2 of the course. In section 2, the total points of the two exams earned by students were in a range from 34 to 200 points. Nine (9) students

scoring total points in a range from 173 to 200 points were identified as the leaders of design teams 1 through 9 for the assigned design project. The same design project was assigned to both sections of the course.

Deliverables for the project included a detailed team report and an individual report submitted by each team member. The following instructions were provided for the reports.

Team Report Requirements

The following instruction was provided for students in writing their team project report.

- Submit a detail report describing all design alternatives (use 12-point font size and 1.5 or double spacing). Limit the text section to 20 pages maximum.
- Prepare a detailed team report in words and equations. The Text section of the report had to be divided into several sections and subsections (include headings and sub-headings) that includes the followings:
 - Abstract: Include a few sentences that briefly describes the design project and the final design.
 - Problem statement (you may just copy the statement provided to you)
 - Introduction (define design specifications, realistic constraints, and design variables) define:
 - design specifications and standards
 - realistic constraints,
 - design variables
 - Analysis (include main equations, main diagrams, and tables in the text section. Number equations, figures, and tables (use the textbook format as a guide). Included the detailed calculations, computer programs, in the appendices.
 - alternative design considerations
 - Results and discussion (include figures and tables in the text section). Continue numbering figures, and tables in sequence)
 - Conclusion describe the final selected design
 - Student Outcome 2 (SO-2) in the course syllabus states “an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.” Describe which one of these topics are addressed in your design
 - List of references. References must be linked to the statements used in the text.
 - Appendices. Include detailed calculations, program listings, and outputs that supports your design.
 - Include captions for table and figure and paginate the report (use the textbook as a guide).
- Attach a log sheet for each team meeting with the signatures of members attending that meeting.

A rubric was used to evaluate team reports. A copy of the rubric is included in Appendix A.

Individual Reports Requirement

Each team member was asked to:

- submit a separate typed summary report describing the project and the results. Maximum one page (single space) or two pages (double space).
- attach team member evaluation form (peer evaluation form) to their individual report. Rate their contribution to the team project and evaluate each of the other team member contributions to the project (instructions and rubric are provided further down in this document)

The design project had a weight of 10% on the final grade. The individual score for the design project was based on several factors that included the team report score, individual report score, and peer evaluation. Assignment of individual team member score for the design project is described below.

Every team member evaluated their contribution to the project plus the contribution of all other team members. A peer evaluation form that each member filled out is included in appendix B. From the numerical information provided in form, a factor (F) is determined for each team member and is applied to the team grade to adjust the individual member's grade. The following formula is used for determining the team member adjusted grade.

$$\text{Team member adjusted Grade} = (\text{Team project grade}) [(F) (0.5) + (0.3)] + (\text{Individual report grade}) (0.2) \quad (1)$$

If $F = 1.0$, that signifies that each member of the team has made equal contribution to the project. If $F < 1.0$, indicates that the team member did not contribute to what was expected. If $F > 1.0$, then the team member contributed to more than what was expected.

Determination of the Factor F and Its Application

An example of the ratings obtained from each team member in a 4-member group shown in a Table 1. For an equal share contributor for a four-member team, the equal share value would be 25% per member. As shown, the horizontal rows must equal 100, or 100%. One can quickly see how each member rates themselves because these numbers are on the diagonal of the matrix. The numbers in the columns are averaged and then divided by 25 in this case to get the F factor for each member. The actual numbers in the table will be different as it is based on each member evaluation. For an equal share contributor for a five-member team, the equal share value would be 20% per member.

**TABLE 1
EXAMPLE OF RATING SCHEME TO DETERMINE F FACTOR**

	Rating of A	Rating of B	Rating of C	Rating of D
Member A ratings of all members	27	24	24	25
Member B ratings of all member	25	30	23	22
Member C ratings of all members	25	25	25	25
Member D ratings of all members	25	27	25	23
	avg=25.5 25.5/25=1.02	avg=26.5 26.5/25=1.06	avg=24.25 24.25/25=0.97	avg=23.75 23.75/25=0.95

For section 1 the F value was in a range from 0.64 to 1.5. For section 2 the F value fell in a range from 0.48 to 1.34.

Fall 2019 Team Formation in Heat Transfer

In fall 2019, the same process as the one used in fall 2018 was employed to form teams in two sections of Heat Transfer course. Except, in the Heat Transfer course, the team formation occurred right after the first exam. In this course, the team members not only were required to complete their design project

together, but they were also encouraged to study together and brain storm as they work on homework assignments. The goal was to improve student success in the course, with the possibility of higher performing students could help weaker students to learn the course materials. Again, students with the highest score were assigned as team leaders, and other students were distributed among the teams based on their performance on the first exam in order to balance the talent among the teams. As an incentive the team members were awarded bonus points added to their grades, if those students in the team who had received low grades in the first exam showed improvement in the remaining exams. After each exam each student was required to submit a peer evaluation of their team members, assessing the participation by each team member in the scheduled group meetings.

The Heat Transfer course syllabi were the same for both sections of the Heat Transfer course and the same grading scales were used in both sections. The three midterm exams were common; given at the same time and location outside the scheduled class time. A common final exam could not be arranged, since the final exam time for each class was scheduled by the university and could not be changed by the instructor. Students' grades for homework assignments, quizzes, exams, and a design projects were the basis for the final grades. The design project counted for 10% of the final semester grade. The two sections of the Heat Transfer course had enrollments of 68 and 40 students, respectively. A design project was assigned approximately one month prior to the end of semester. The project could not be assigned earlier since not all the topics related to the design project was not covered prior to the time of design project assignment.

For the selection of team leaders in fall 2019, the total points earned by each student in the first exam was sorted in spreadsheets for each section. In section 1, the total points earned by each student were in a range from 34 to 100 points. Fourteen (14) students scoring total points in a range from 90 to 100 points were identified as the leaders of teams 1 through 14. Each remaining student was asked to select three teams as the first, second, or third choice and submit their selections to the instructor. The instructor first assigned one student whose grade for the first exams was among the lowest 14 grades to each of the 14 teams. Then two or three more students were added to each team based on students' performance in the first exam. Again, attempts were made to honor students' choices on team placement as much as possible and to keep the diversity of student performance in the first exam similar for all the 14 teams. A similar procedure was used to form design teams in the second section of the course. In section 2, the points earned by students were in a range from 22 to 100. Nine (9) students scoring points in a range from 86 to 100 were identified as the leaders of 9 teams. The same design project was assigned to both sections of the course.

Similar to design project assigned in fall 2018, deliverables again included a single detailed team report and an individual report submitted by each team member. The instructions for the writing reports, rubrics for evaluating team project report, and the peer evaluations form were the same as those used in fall 2018. The method of individual grade assignments to each member of teams were almost the same as the one used in fall 2019, except the equation for calculating the individual grades was slightly modified. For the Heat Transfer design project, the following formula was used:

$$\text{Team member adjusted grade} = (\text{Team report grade}) [(F) (0.5) + (0.2)] + (\text{Individual report grade}) (0.2) + \text{Peer evaluation} (0.1) \quad (2)$$

The main reason for the modification was that some students did not submit their peer evaluation forms in fall 2018. For section 1 in fall 2019, the F value was in a range from 0.19 to 1.54. For section 2 the F value was in a range from 0.70 to 1.40.

STUDENT FEEDBACK

During the last week of the fall 2019 semester, a survey was conducted in both sections of the Heat Transfer course to seek students' feedback on team formation method used, how well the teams worked together on the design project, their experiences with the study groups, and recommendation for forming teams in the future. The survey included 21 statements asking for students' feedback on various topics. Statements 1 through 4 were related to team formation process; statements 5 through 9 were related to

students' team performance during the semester; questions 10 through 13 were related to other possible methods of team formation; and questions 14 through 21 were related to group study. A total of 88 students from both sections participated in the survey. For statements 1 through 14 and statements 18 through 21, the participants were asked to rank their agreements with each statement as (5) strongly agree, (4) agree, (3) neutral, (2) disagree, (1) strongly disagree. The results of student survey are summarized in the following paragraphs.

Table 2 shows the results of student survey regarding the method used for the team formation for the design project and the study groups. The majority of students either strongly agreed or agreed with the way the team members were selected and other students placed in each team. Even though students did not have full control of selecting their own team, they were given at least three choices for selecting a team leader to work with. The average scores for the level of agreement with four statements in this area were in a range from 4.1 to 4.3.

Table 3 exhibits the results of student survey regarding how well the teams functioned during the completion of the design project. The majority of students either strongly agreed or agreed the way team members worked effectively together, participated in group discussions, contributed to the work required for completing the project, and finding a common time for group meetings. Only few students indicated problems in these areas. The average scores for the level of agreement with five statements in this area were in a range from 4.3 to 4.7.

TABLE 2
FEEDBACK ON DESIGN AND STUDY GROUP TEAM FORMATION

#	Statement	5	4	3	2	1	n	Ave
1.	The team leaders were selected based on how well they performed on the first exam. I liked this method of team leader selection.	45	19	17	6	1	88	4.1
2	The rest of students were given an opportunity of identifying three individuals who were selected as team leaders and each student requested to be assigned to a team lead by one of those three individuals. I liked the choice given to me for team assignment.	52	18	11	4	2	87	4.3
3	The instructor formed the teams by honoring students' team leader request and balancing teams based on students' performance on the first exam (each team included members who received low grades as well as those receiving high grades on the first exam). I liked this method of team formation helping teams be balanced.	44	20	13	7	4	88	4.1
4	Overall, I liked the way the teams were formed this semester	44	20	13	8	2	87	4.1

TABLE 3
FEEDBACK ON HOW THE DESIGN TEAMS FUNCTIONED

#	Statement	5	4	3	2	1	n	Ave
5.	My team members worked effectively together to complete the design project.	56	25	2	3	2	88	4.5
6	All team members participated in discussions during team meetings.	53	20	8	4	3	88	4.3
7	All team members contributed equally towards the completion of design projects	52	16	13	4	3	88	4.3
8	My team was able to find agreeable times among members for meetings	50	27	6	3	2	88	4.4
9	My team had no interpersonal conflicts among team members.	72	11	2	0	3	88	4.7

Table 4 summarizes students' feedback on possible ways of selecting team leaders and assigning team members. Students' agreements on considering the overall GPA for the selection of team leaders was mixed. In the written comments some students indicated that one can have a very high GPA, but might not be very good in a particular course. They felt that for selecting a team leader for the heat transfer team project, it is better to consider students' grads in thermodynamics and fluid mechanics, as well as their performance in the first heat transfer exam. The average score for the level agreements with statements listed in Table 4 were in a range of 2.9 to 3.8.

TABLE 4
FEEDBACK ON OTHER POSSIBLE METHODS FOR FUTURE TEAM FORMATION

#	Statement	5	4	3	2	1	n	Ave
10.	Next semester, the instructor should use students' overall GPA for selecting team leaders	13	16	21	21	17	88	2.9
11	Next semester, the instructor should assign students to the teams in such a way that each team has members with high GPA as well as low GPA	19	16	26	15	12	88	3.2
12	Next semester, students should be able to volunteer to be team leaders	30	31	13	7	7	88	3.8
13	Next semester, students should form their own teams	22	21	19	15	10	87	3.3

As shown in Table 5, the majority of students either strongly agreed or agreed that that group studies contributes to the learning process. The average score for the level of agreement with the statement was 4.3.

Item 15 on the survey asked students whether they participated in the group studies. Seventy one (71) participants responded affirmatively, and 14 students stated that they did not participate in the group studies. A few students who responded positively, they indicated that they did not participated in the group that they were assigned to. Instead they studied with their own friends. For those participants who responded negatively to question 15, question 16 asked if any of the following factors was the reason for non-participation: a) the team leader never called for a group study meeting, b) I do not enjoy group studies, c) I did not have time for group study, and d) I had time conflict with arranged group study times. Seven (7) students selected option (a), 5 chose option (b), 8 picked option (c), and 4 give the reason (d). Item 17 asked students how many times they participated in the group studies, if any. The responses were in a range from ones to more than 20 times. The average for the number of times of participation in the group studies was approximately 6 times.

TABLE 5
FEEDBACK ON PARTICIPATION IN GROUP STUDIES

#	Statement	5	4	3	2	1	n	Ave
14.	I believe that group studies contribute to the learning process	37	38	9	2	0	86	4.3

Table 6 presents students feedback on whether they benefited from group studies or if they were able to help other team members. The majority of respondents indicated that the group studies helped them in learning the course material, improved their performance in the exams, and learned from other team members. A number of respondents indicated that they were able to help other students in their team to learn the course materials.

TABLE 6
FEEDBACK ON GROUP STUDIES BENEFITS

#	Statement	5	4	3	2	1	n	Ave
18.	Group studies enhanced my learning process	29	37	17	2	2	87	4.0
19	Group studies improved my exam performances	25	24	27	7	4	87	3.7
20	I learned from other team members during group studies	30	34	15	5	3	87	4.0
21	I was able to help other members to lean during the group studies	25	35	21	3	3	87	3.9

The survey also asked students to suggest a better method for team formation or any other comments they might have. The followings are some of the comments made by respondents. It should be noted that only a fraction of respondents provided written comments. They either liked the method of team formation in fall 2019, or they preferred forming their own teams.

Students Suggestions for Future Team Formations

On the survey questionnaire students were asked if they can suggest a better method for team formation of group project. The following is a partial list of the student's response to the question

- GPA method.
- If possible to assign senior design teams together.
- Works good (well) the way you did.
- GPA, volunteering, perhaps the teams should have group HW, make the HW load lighter.
- Your method of forming groups is fine. However, I am not able to properly take advantage of the group mostly due to the fact I do not have time. I barely have time to take care of myself much less help others. I do enjoy helping others I just can't right now. I have two children under one year of age and a full-time job.
- I think the teams should meet out the end of the first class teams are assigned so everyone knows who is in their group.
- No, I thought this method was good.
- Students should have the choice of forming their own groups. By grouping up with familiar faces, you understand how both you and like colleagues work with one another. This saves time in trying to get the project done instead of having to be forced to get to know someone you've never seen before.
- I think the current group selection method works fine, however I didn't get the team that I wanted and I think that if a member is not satisfied with his team he should have the opportunity to switch with someone.
- No, I liked it balanced by grades on the first exam.

- GPA-based and allowing for leader volunteering is a good idea.
- Each student picks their own groups.
- Perhaps have teams formed sooner, so study sessions can begin earlier.
- Take into consideration available meeting times for the members like you do for recitation.
- I think that the professor should keep using the same method, it really worked for me.
- The method used this semester was a good method, I would prefer to keep that method.
- I would have liked to be able to pick our own teams. We are all far enough along in the program to know who you work well with or are not compatible with.
- Additional points should not be awarded to team leaders. Groups should be formed by individuals, not professors.
- Some member from our team had busy work/class schedules.
- I loved the way it was. Got to network w/ new people.
- Same method, by exam grades or if class want to form own groups.
- I think the way it was done works the best. It allows people to work with others they normally wouldn't have.
- I think there should be a list of people from the class that qualify as team leads based off of GPA and test scores. Then they get to decide who they want in their groups and if they want to be leaders.
- I think leaders should be chosen by instructor. Team members should then be selected by leaders since this how real-world teams would be formed. If this was a real-world project I would hire qualified individuals that I feel would better the company.
- The current method is fine.
- Volunteers and self-formed groups. Most students were in SD1 and having two to three groups to meet with every week is tough with all of the due dates.
- I would suggest if teams could be formed by students. It is easier to study with people you choose. It is also difficult to meet at mutual time when all members have jobs at different times.
- I believe the method used this semester was decent and fair.
- Volunteers for group leaders and then the way it was done after group leaders were chosen.
- People who did well in thermo or fluids should be considered.
- Fine as is.
- Let students volunteer as team leaders. If not enough students volunteer then select the remaining number based on GPA.
- I would have liked to pick people I know and could hold accountable, everyone I reached out to meet with did not respond to me until just before the due date.
- I liked the used method.
- I generally dislike group projects and study better on my own, so I'm not a good info source for team formation ideas.
- Let teams from each other.
- Choose team leaders based off of GPA and how they did in similar courses. Also balance teams with people that are in Senior Design and those that aren't.
- Have the teams submit a work update form midway to the project due date for proof that everyone is contributing.
- Give students a deadline for team formation. After the deadline assign students without teams to teams.
- Letting each other pick teams and allowing the student with good management skills be the leader. Just because someone gets good grades doesn't mean they can manage a team well. That takes different set of skills.
- I think that the way it was done is probably the fairest way to do it. But personally, would have preferred to select my own team.

- Not much that I can really say about the team selection was pretty good overall.
- I like the idea of volunteering for team leader. Those who volunteer tend to reach out to team members and form agreeable group study schedules.
- The leader needs to not only know the subject but he must also be confident and ready to lead.
- Allow students to form groups on their own but give restrictions or say that you will have final say based on grades.
- I thought the formation of teams was fair.
- Overall, I believe each team should pick their team members and within the group, decides who shall be leader.
- I enjoyed the way it was done.
- Voluntary group leaders, instead of assigned
- This method worked great for us, GPA doesn't define a student in a certain class but tests do.
- I liked choosing team leaders after 1st exam or highest GPA. Don't let students make their own team.
- I liked the method that was chosen for the group project because my team worked very well together.
- I liked how you chose the leaders.
- I think letting students volunteer to be team leaders would be a good idea, and then resort to assigning team leaders if not enough students volunteer.
- Volunteer team leaders.
- Let group leaders also have an input on who is in their team.
- 1.) Students should pick their study groups.
2.) Have students turn in weekly or bi-weekly sign-up sheets for points
3.) Make participation mandatory or at least make attendance of at least 2 hours per week worth some points
- Have students select their teams is good because they know who studies similar to them and therefore can learn more effectively.
- High GPs work, honor the option of volunteer if you want and make your own team would be nice.
- Group leaders based on their engineering GPA.
- Exam score seems to be a good method of team selection.
- I liked the method of team leaders. However, I think group size should have been mostly groups of 3 and only some groups of 4. No groups of 5.
- Having a good first exam has no bearing on ability to act as a leader. I recommend not assigning the role of leader. I think most students would be better suited forming their own groups.
- Strictly formed from some performance metric. (First test in class or overall GPA). Do away w/ students choose a team leader.
- I thought this method was pretty good.
- I think they should be based on both GPA and first exam score. They should also be balanced such that one group does not have more than one person with a low GPA and/or low exam score.

Other Students' Suggestions

Students were asked to feel free to make any other suggestions related to the team formations. The following is a partial list of suggestions.

- Ask people if they are able and willing to be a team leader.
- Group leaders should not be determined based upon one exam. It should be an interpretation of how they performed in Thermo 1, 2, and Fluid Mechanics. Also, overall GPA should play a role in determining team leaders for the project.

- No suggestions, great team formation.
- I already have a group that I study with, that I have been through several classes with by
- Perhaps at the start of the semester give a survey on available times students would be able to meet and from teams based on performance and availability.
- I feel that students with a high GPA usually rather study on their own, than in groups. So, picking students with high GPA as team leads can be beneficial by helping students work better in groups. If teams are formed on their own, teams will more than likely receive a higher grade on the project.
- Assigning students with low grades to groups with students with high grades usually leads to the higher grade students doing more work.
- I think that picking teams based off the first test isn't the best way to choose teams just because some people, like me, tend to do badly on the first test but good on the rest of the test while others do well on the first test and badly on the rest. I think picking teams off of GPA would be a better method.
- Choosing groups forces individuals to work w/ those they may not normally choose which is a good experience. (Don't allow students to choose).

CONCLUSION

Students should learn to function in teams as part of their undergraduate engineering education. Instructors should require students to either study in groups and/or complete design projects in teams. The authors have used and recommend a performance-based team formation method. One benefit of this method is that it is relatively easy to implement in comparison to other more elaborate schemes. The key is to gain some early academic performance data and then select team leaders and distribute other members to have balanced teams. Another key is to incentivize students to participate in the team and have some peer evaluation of the teams. Although this approach may appear rather crude and dictatorial, the feedback from students has been surprisingly positive, hence the method and results are shared here.

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**APPENDIX A
LIST TEAM MEMBER NAMES**

1.	2.	3.				
4.	5.		6.			
Points	1	3	5	Basic Score	Weight 1-4	Full Score
Report divided into sections	Not divided into meaningful sections		Divided into meaningful sections		1	
References	No reference provided	A reference list provided, but not linked to information in the text	A reference list provided and linked to text content		2	
Pagination	Report not paginated	Report is paginated			1	
Equations presented and numbered	Not numbered		Numbered		1	
Figures and Tables are numbered and provided captions	Not numbered and has no caption	Numbered, but has no caption	Numbered and has caption		1	
Writing quality	Not clear, has many grammar and punctuation errors	Clear, but has many grammar and punctuation errors	Clear and no or very few grammar and punctuation errors		2	
Design problem statement	Not included	Included, but it is complete or very clear	Clearly stated		1	
Design specifications	None specified	Specified, but incomplete	Clearly specified		1	
Design constraints	Not identified	Identified, not all realistic	Identified and all are realistic		1	
Design variables	Not identified	Identified but incomplete	Well defined		1	
Alternative design consideration	None considered	Limited consideration	Several consideration		4	
Method of approach	None or poor description	Adequate description	Well described		2	
Design analysis	Incomplete	Limited	Complete		4	
Economic analysis	Not included	Acceptable analysis	Full analysis		1	
Global, economic, environmental, and social context.	Not discussed	Discussed some of the areas	All areas were fully discussed		1	
Quality of report	Poor	Acceptable	Excellent		4	
			Total		28	

APPENDIX B
TEAM MEMBER PEER EVALUATION FORM
ATTACH THE COMPLETED FORM TO THE INDIVIDUAL REPORT

Team Number _____

List Team member names

1.	2.	3.
4.	5.	6.

Rate your performance during the reporting period. Use the following abbreviations:

E. Excellent **G.** Good **A.** Acceptable **U.** Unacceptable

Then rate your teammates' performance. Note: *Information held in confidence by your Instructor.*

Teamwork Item	Team Member (print last names in blank spaces below)				
	<u>Self</u>				
Participated in team deliberations					
Listened well					
Kept deliberations on track					
Respected individual differences					
Solved problems openly, authentically					
Completed Individual tasks on time					
Completed Individual tasks thoroughly					
Assisted other teammates					

Determine an "overall" rating for yourself and your teammates using the following scheme:

Rating Characteristics

- 1 Outstanding Contributor - totally involved, sacrificed for team, carried others.
- 2 Hard Worker - did more than "fair-share," stepped up when needed, volunteered to help others.
- 3 Fair-share Contributor
- 4 Lazy or Do-What-ever – "tell me what to do, and I will do it."
- 5 Negative / Destructive - destroys effectiveness of team, immersed in own ideas, nothing is done "right."

Overall teamwork rating					
Percent Contribution ($\Sigma = 100$)					

Comments:

Print Name: _____

Signature: _____

Date _____