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# Senior Capstone Team Formation Based on Project Interest: Team Selection by Students Compared to Team Selection by Instructors

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## Abstract

Assigning teams in large courses is logistically challenging and students are sometimes unhappy with their assigned team. This is exacerbated when the project work extends over multiple terms and teams have unique projects. Giving students some agency in team and project selection is one way to improve their project experience. This paper examines two key questions: (a) What is the best way to incorporate student interests into the team-forming process? (b) What impact does the team-forming process have on the student experience throughout the project?

We consider two different approaches to giving students agency in the team formation / project selection process that have been implemented in our capstone course. One approach has faculty forming teams outside of class based on student surveys of project interests, skills, time availability, and team preferences. The alternative method enables students to form their own teams in a dynamic faculty-guided setting: Students place nametags on their top project posters, speak with other interested students, and move their nametags as needed until each project had teams with the appropriate size and skillset.

Teams formed using these two approaches have completed a full year-long senior design project experience. Throughout these experiences, we collected data to help answer our two key questions. We used student surveys about the experience and the class, peer feedback on team dynamics, focus group discussions, and faculty observations. The results are inconclusive: The differences between the two approaches are small, indicating that either approach could be used to enable student agency in the team-forming process.


## Introduction

One of the greatest challenges with a year-long senior design project is team formation. A number of different techniques for this have been described in the literature (see Barkley, *et al.* [1] for review), including random assignment, allowing the students to self-select, and having the instructor assign teams. Assigning teams in large courses with multiple projects (e.g., 160 students and 50 projects) is logistically challenging [2] and students are sometimes unhappy with their assigned team and/or project. Computerized algorithms (www.catme.org) have been developed to maximize instructor-defined parameters, including diversity, GPA, times available, and different skill sets [3], but students still lack agency in their final team assignments.

In our Mechanical Engineering Department, we have a year-long capstone senior design project course. Projects are typically industry-sponsored, but some are for non-profit agencies or for individual faculty members. Throughout the year, students meet for three hours twice weekly in a design lab. The project teams are typically 3-4 students each, and six different project teams are placed in each lab section. We deliver content using a flipped approach, covering topics such as design for manufacturing, Quality Function Deployment, brainstorming, Failure Mode & Effects Analysis, and team dynamics. During the labs, we discuss this content, lead class activities, and guide students to apply the content to their individual projects.

To form student teams, traditionally we have had students submit surveys stating their project interests, skills, time availability (for lab enrollment), and team preferences, then faculty members formed teams to maximize project interest while considering other factors (resulting in 'faculty-formed' teams). Believing that choice is the primary factor in student motivation [4], and that this motivation will lead to the highest team performance, last year we implemented a variation of the Mingling Method described by Aller *et al.* [5]. For these student-formed teams, students individually ranked projects and listed their specialized professional skills before coming to lab. In class, they placed nametags on their 1st (pink), 2nd (orange), & 3rd (green) choice projects on posters around a room and spoke with others interested in each project. Students then moved nametags as needed to form teams with the required skills and team size, and occasionally faculty intervened to adjust team sizes (resulting in 'student-formed' teams).

Our research questions were: (a) What is the best way to consider students' interests when forming teams, while also integrating research-based team-forming strategies? and (b) How does the team-forming approach affect student experiences, student learning, and project outcomes?

We look at three different characteristics of our teams, and had the following hypotheses regarding diversity, dynamics, and student satisfaction:

- Team Diversity. Hypothesis: Allowing students to form their own teams might result in more homogeneous teams.
- Team Dynamics. Hypothesis: Allowing students to form their own teams might reduce team friction.
- Student Satisfaction. Hypothesis: Allowing students to form their own teams might improve their project and team satisfaction.

In this paper, we present our two team-forming approaches (faculty-formed and student-formed) and then discuss the measures and results obtained when assessing the student experience.

## Faculty-Formed Teams

Traditionally, Mechanical Engineering senior project teams at our university are formed by the senior project coordinator based on information that the students provide in a Project Preferences Survey (PPS). The most important criteria used in this team forming approach are the students' project interests and relevant skills. Prior to completing the survey, students had access to detailed information about each project, and could attend sponsor presentations. Using information from the survey, the course coordinator has the task of balancing the factors of student skillsets, desired projects, team compatibility, and scheduling to create the teams.

In January 2019, teams were formed by the course coordinator using this traditional faculty-formed method. The PPS consisted of two pages: On the first page (Figure 1), students state their level of interest in each proposed project. On the second page (Figure 2), students provide supplemental information about their availability, time commitment, skills, and team member preferences.

1. Place an 'X' in the appropriate column to show your interest each of the projects listed below:
   (Please rate at least five projects 'Best,' five projects 'Good,' and five projects 'Okay')
   If you wish, you can rank your top projects (1 = most interest) instead of entering an X.

| | Best (≥5) | Good (≥5) | Okay (≥5) | Prefer Not | Definite No |
|---|---|---|---|---|---|
| P01 - e-Cool Pillow Concept | | | | | |
| P02 - Bicycle Drivetrain Power Transmission ... | | | | | |

Figure 1: Extract from First Page of Project Preferences Survey

2. What is your major? _____

3. Circle your current ME 428 lab section (leave blank if not yet enrolled)

   01 (Elghandour, TR 8-11) 02 (McFarland, TR 12-3) 03 (Ridgely, TR 12-3) 04 (McFarland, MW 3-6)

4. Sometimes we ask students to change labs to form project teams. Circle all lab times you are willing and able to attend? (NOTE: If you circle a time, you are committing to change if we ask you to!)

   Tue/Thur 8-11am Tue/Thur 12-3pm Mon/Wed 3-6pm

5. Outside of lab time, about how many hours per week do you expect to spend working on your senior project? _____

6. Circle your Student Machine Shop Tag status:

   Red Tag Only Yellow Tag No shop tag

7. Place an 'X' in the appropriate column to rate your current skill level in each of these areas:

| | Excellent | Good | Okay | Fair | Poor |
|---|---|---|---|---|---|
| Project Planning | | | | | |
| Technical Writing | | | | | |
| CAD (Solidworks) | | | | | |
| Computer Programming | | | | | |
| Manufacturing / Machine Shop | | | | | |
| Mechatronics | | | | | |
| Composites | | | | | |
| Stress Analysis (by hand) | | | | | |
| Thermal Analysis (by hand) | | | | | |
| Fluids Analysis (by hand) | | | | | |
| FEA (Finite Element Analysis) | | | | | |
| CFD (Computational Fluid Dynamics) | | | | | |

8. If there are any students you feel you cannot work with, list them here (no more than three):

   _____

9. If you are more interested in being on a certain team than on a certain project, staple your Project Preferences Survey with one, two, or three other students' surveys. We will keep your team together, but you will get lower priority in the project you work on.

10. For each of your top 3-5 projects, you may attach short (1-2 paragraph) explanations of why you should work on that project. For example, relevant background or skills, strong career interest, etc. Be sure to identify the Project # and Name in each explanation.

Figure 2: Second Page of Project Preferences Survey

After collecting the surveys, the course coordinator formed teams using a two-stage process. Initially, students were grouped based on time availability (questions 3 & 4) and project interest (question 1). This resulted in a few very large groups (the popular projects) and many small

groups (less popular projects). The second stage involved using the remaining questions to ensure each team/project had the right size, skillset, and compatible team members: Question 5 was used to ensure team members would share a similar work ethic. Questions 2 and 7 were used for certain projects to ensure important skills (e.g. mechatronics, FEA) were represented on the team. Question 7 was additionally used to balance the other skills on a team (e.g. planning, writing, CAD, manufacturing). Question 8 was used to ensure known personality conflicts wouldn't interfere with team dynamics. Question 9 was used to keep certain students together (often by moving them from a popular project). Question 10 was used for the popular projects, to refine the final team membership. Question 6 relates to certification for using certain machine tools, and was not used for team-forming. The process took about ten hours to form 22 teams across three different lab times.

Student-Formed Teams

In contrast to the traditional faculty-formed teaming method, in September 2018, the senior project faculty decided to allow students to create their own teams (student-formed teaming). As with the traditional teaming method, the students were given detailed information about the projects prior to team forming, including project Q&A sessions with sponsors. The actual team forming took place during the scheduled class time, using the Mingling process as described in Aller, *et al*. In preparation, faculty created an 11"x17" poster (Figure 3) for each project and taped them to the walls. The posters included the proposal number, name, and sponsor at the top and a box for any special skills required near the bottom. The stage was set by writing out initial instructions (Figure 4).

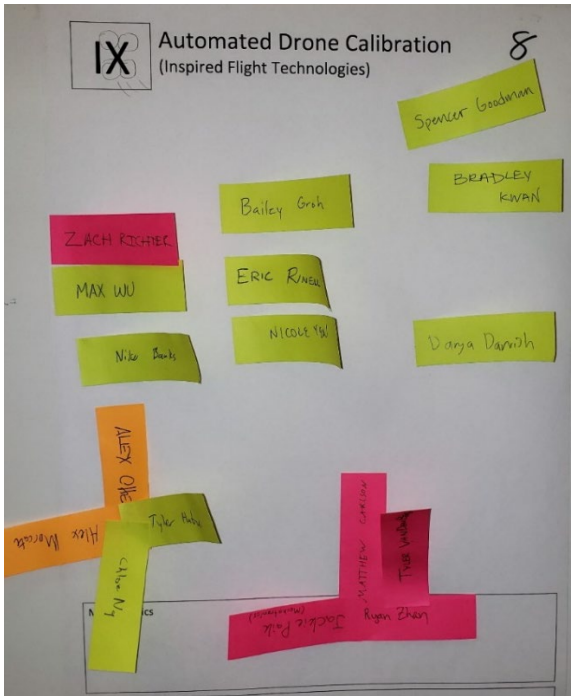


Figure 3: Example Project Poster

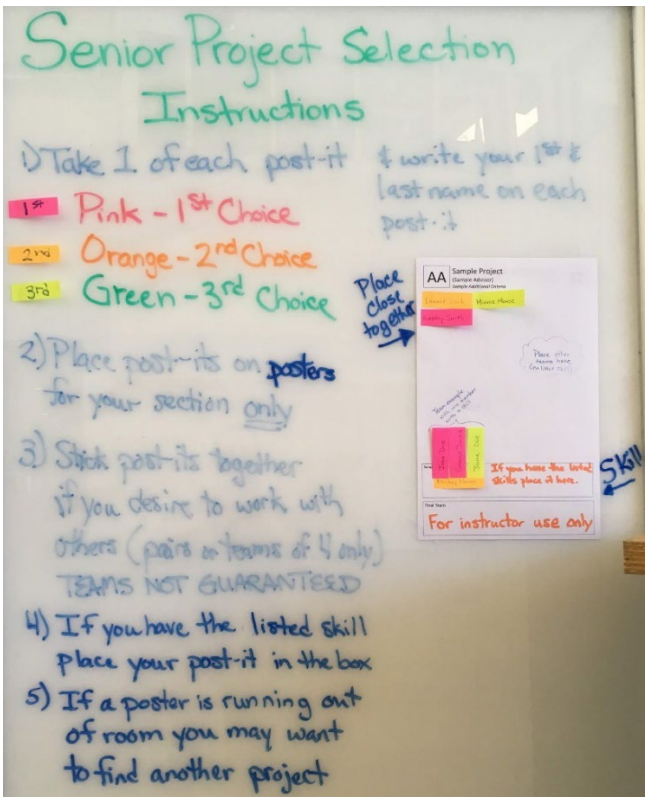


Figure 4: Instructions for Mingling

Class started by going over the instructions and giving each student one pink (1st choice), orange (2nd choice), and yellow (green - 3rd choice) sticky note on which to write his or her name. Then, students circulated the room and placed their sticky notes on their top three projects. If a student possessed the special skill for a project, they were entitled to put their sticky note in the skill section of the poster. Groups of students who wanted to work together were instructed to attach their sticky notes. Two examples of this can be seen in Figure 3. While placing sticky notes, students spoke with others interested in the project to discuss skill sets and to make a general determination of their compatibility as teammates.

During each lab time, up to 75 students mingled and placed sticky notes on up to 25 posters. We allocated about 45 minutes for this mingling process. Students were encouraged to monitor the number of sticky notes, colors, and names on a particular project poster in order to gage the level of interest and note which other students were interested in the project. Based on this information, they had the opportunity to adjust their choices. Pictures of the activity as it progressed are shown in Figure 5.

After this first 45-minute round, we asked the students to stop and reflect: Did their first-choice project include people with the required skill set(s)? Were too many people interested in that project as their first choice? Were enough people interested in the project to get a team of four? We asked them to consider moving to their second or third choice if their first choice had more than four people. During this reflection period, we (the faculty facilitators) highlighted those projects that had fewer than four interested people and suggested students consider moving their sticky notes to those projects. We also highlighted projects for which there appeared to be

inadequate skills. We reiterated that each project should have a team of four people, then we asked them to make a final decision regarding their choice of project. After this short time of reflection, we started the process again, hoping that teams would coalesce.

Figure 5: Students discussed the project, skills, and got to know each other during the process

After the reflection period, some students went to the poster of the project for which they had their strongest interest and stayed. Others decided that they would form a team for their second or third project preference, usually because their first project had too many people interested. In some cases, a partial team had formed for a project, but one or two additional team members were required to go forward with the project. In these cases, we attempted to draw students' attention to these partially-formed teams.

After another 45 minutes of mingling, most projects had teams of four students fully formed. In a few cases, more than four students were interested in a particular project and no one student was willing to change their project choice. When this occurred, an instructor would speak with the group and discuss the project and other options. If still nobody would move, then the instructor randomly (eyes closed, point to poster) picked a student to leave that group. Unfortunately, for students who were picked in this manner near the end of the process, the number of projects needing students became noticeably diminished, limiting their choices further.

This process, while chaotic, took only two hours to complete, so it was more efficient in terms of faculty time than the traditional method. Of course, those two hours were during class time, so the total person-hours taken to form teams was higher. The trade-off was that students were able to have more agency in their project and team selection.

Student Experience: Team-Forming Survey

One aspect of the student experience in capstone design is the team-forming process itself. To see whether the specific team-forming approach had an influence on their experience, students in each course were asked to complete a survey about the team-forming process a few weeks after project kickoff. The survey questions are shown in Figure 6. Students were also asked to enter an email address if they were willing to participate in a focus group discussion (next section).

1) How would you describe your emotional state during the team-forming process? (check all that apply)
   *Very stressed. A little stressed. Worried about finding out what my project would be. Excited about finding out what my project would be. Excited about finding out who my teammates would be. Worried about who my teammates would be. Calm. No different than starting any other new class or project. Happy that I had some control over choices of team and project.*
2) What strategies did you use during the team selection day? How important was each strategy to you? (check all that apply)
   *Chose to be on a team with my friends. Avoided being on a team with certain people. Chose my favorite project and refused to move. Put priority on specific projects. Chose to be with team members who I thought were very hard working. Chose to be on teams I thought would be very diverse. Other strategies. Importance: Very important, Somewhat important, Not very important, No importance at all.*
3) With what you know now, would you have changed your team selection strategy? If so, how?
4) What aspects of the teaming process were most concerning to you?
5) Was the project you ended up on one of your top choices?
   *My top choice. One of my top three choices. One of my top six choices. My seventh choice or higher. Not that important to me – I was more interested in my team.*
6) Now that the project is underway, are you happy with your project choice?
   *Very happy with the project. Somewhat happy with the project. An even mix between happy and unhappy with the project. Somewhat unhappy with the project. Very unhappy with the project.*
7) How happy were you with your teammates at the time of selection?
   *Happy with all team members. Happy with most team members. An even mix between happy and unhappy with my team members. Unhappy with most team members. Unhappy with all team members.*
8) After working with them for a few weeks, how happy are you now with your teammates?
   *Happy with all team members. Happy with most team members. An even mix between happy and unhappy with my team members. Unhappy with most team members. Unhappy with all team members.*
9) Rate your level of agreement or disagreement with the following statements:
   a. The process for assigning teams was equitable for all students
   b. This process should be used in senior project in the future

   *Agreement: Strongly Agree. Agree. Slightly Agree. Slightly Disagree. Disagree. Strongly Disagree.*
10) How important was it for you to have some say in these decisions for your senior project:
   a. Choosing the project I work on
   b. Choosing the team I work with
   c. Choosing my project advisor/coach

   *Importance: Very important, Somewhat important, Not very important, No importance at all.*
11) Do you have any suggestions for improving this process if we use it again?
12) Are there any other comments you would like to share?

Figure 6: Team-Forming Survey Questions

The team-forming surveys had high response rates for both cohorts: 70% (62/88) for the faculty-formed team cohort (January 2019) and 77% (102/133) for the student-formed team cohort (September 2018). While many of the responses from the two cohorts were very similar, there were some differences.

Questions 5 and 6 address one of our key goals for the team-forming process: Matching student interests with projects. The responses to question 5 (Figure 7) show that the student-formed teaming approach was much more effective in assigning students to their first choice project. This statistically significant result provides strong evidence that the student-formed approach was effective. However, the responses to question 6 (Figure 8) temper that conclusion: After a few weeks, nearly two thirds of students in both cohorts report that they are very happy with their project choice. So, after a few weeks on the project, the difference in project satisfaction between the two groups essentially disappeared.

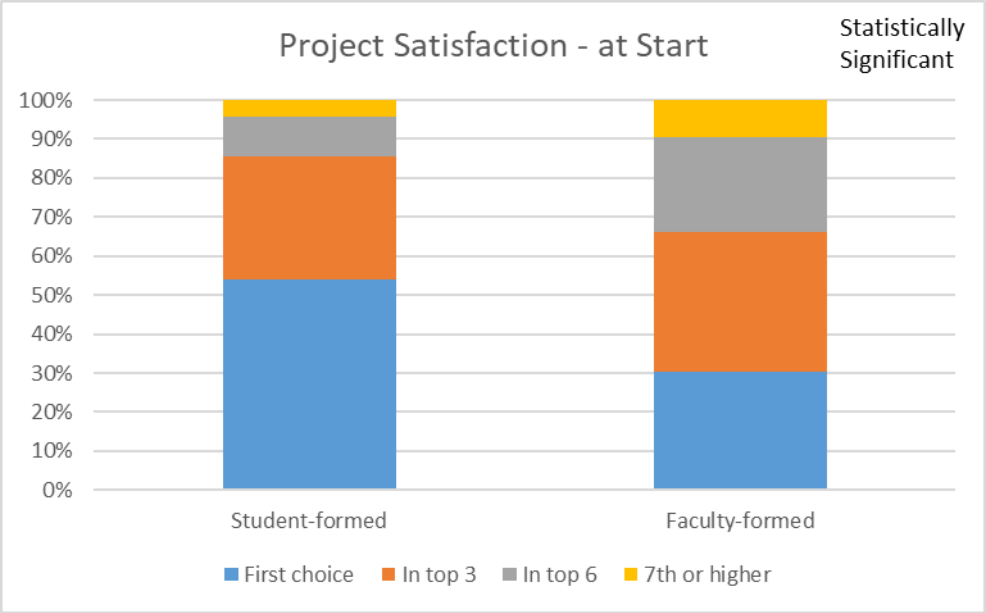



Figure 7: Team-Forming Survey, Question 5 (Top Choice Projects)

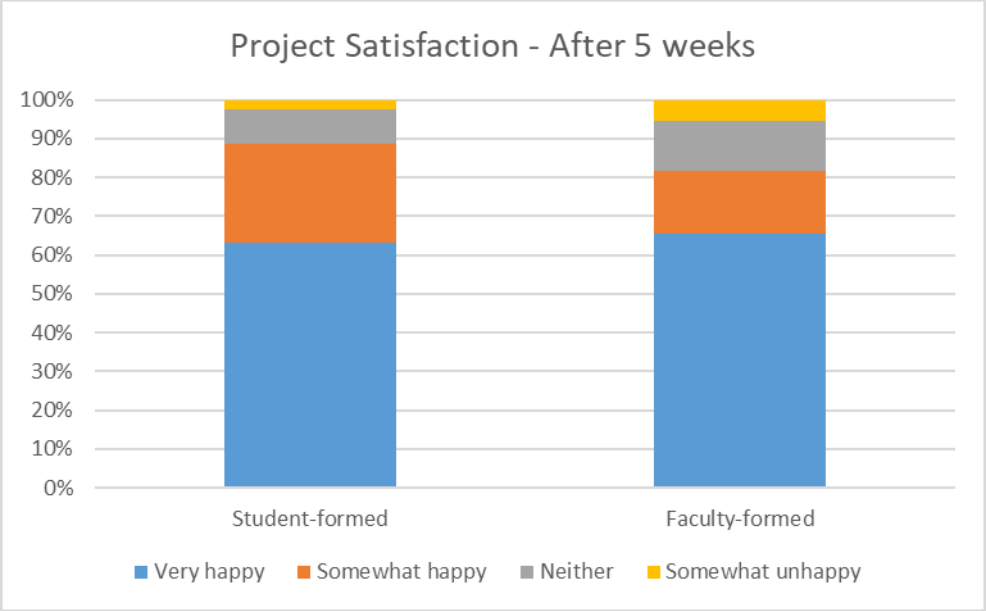
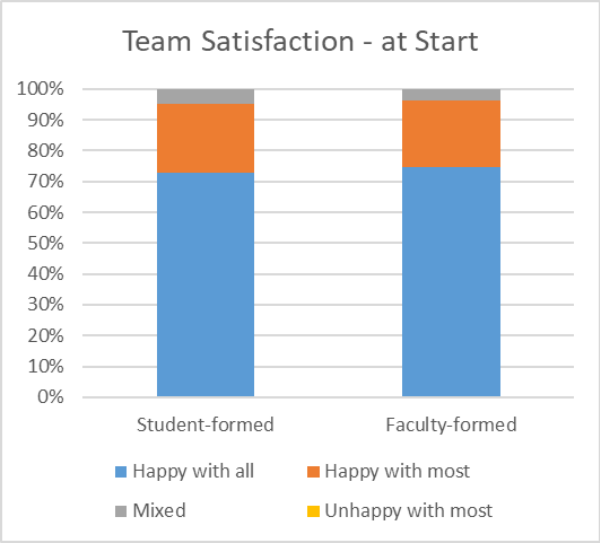


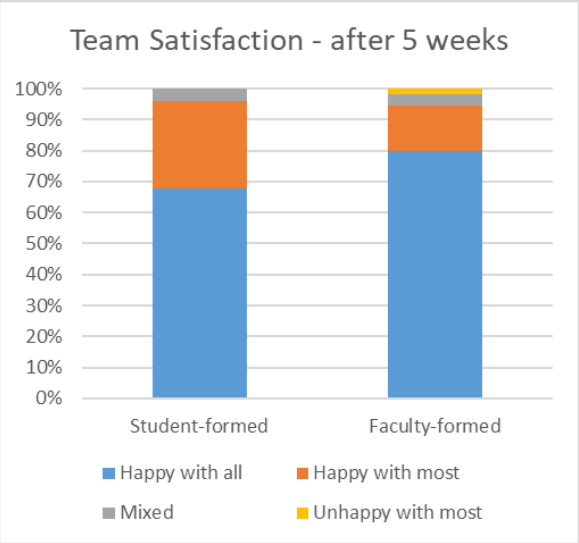

Figure 8: Team-Forming Survey, Question 6 (Project Satisfaction after five weeks)

Questions 7 and 8 examine another key goal for the team-forming process: forming strong teams. In particular, the student-formed teaming process was intended to enable students to self-identify potential personality conflicts and avoid joining teams with those teammates during the forming process. The responses to question 7 indicates no noticeable difference in team satisfaction between the cohorts right after team forming: The student-formed teaming process did not lead to any enhanced initial team satisfaction. Curiously, after five weeks, question 8 responses show a slight drop in the number of student-formed team members reporting they were "happy with all" of their teammates. By contrast, there was a slight increase in the number of faculty-formed

team members who were "happy with all." This difference is not statistically significant, however.




(Question 7)




(Question 8)

Figure 9: Team-forming Survey (Teammate Satisfaction)

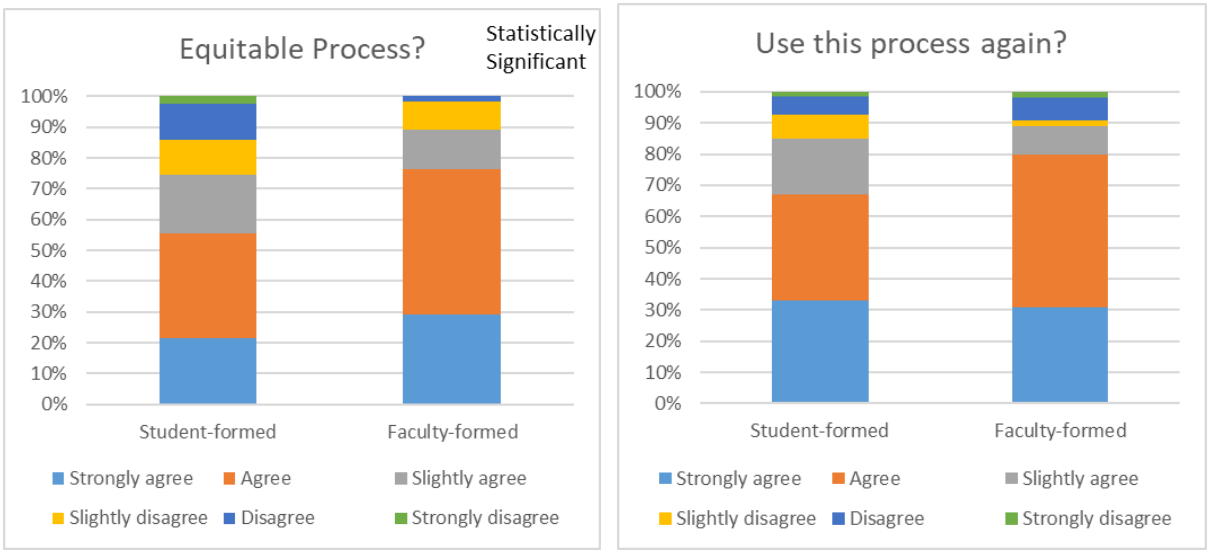
Another important point of comparison between the two approaches is addressed in question 1, the emotional state of the students during teaming. Table 1 shows that students in the two cohorts experienced similar emotional states during teaming, with the exception of their self-efficacy: 50% more of the students in the student-teamed cohort felt happy that they had some control of the process. This is the only statistically significant difference in the question 1 responses, and indicates that the student-formed teaming process resulted in the students feeling more agency, while not significantly increasing anxiety.

Table 1: Team-Forming Survey Results for Question 1 (Emotional State During Teaming)

| | Student-formed | Faculty-formed |
|---|---|---|
| Very stressed | 22% | 18% |
| A little stressed | 40% | 47% |
| Worried about project | 39% | 42% |
| Excited about project | 44% | 40% |
| Excited about team | 27% | 33% |
| Worried about team | 37% | 33% |
| Calm | 10% | 13% |
| Similar to other classes | 7% | 15% |
| Happy I had control | **60%** | **40%** |

Questions 9(a) and 9(b) also provide insight to the student experience (Figure 10). While question 1 and question 5 showed that the student-formed teaming process enabled more students to get their top choice project and feel like they had some control during the process, fewer students in that cohort felt that it was an equitable process: 74% of the student-formed teams had some level of agreement with that statement, while 89% of the faculty-formed teams

agreed with it. This was a statistically significant difference. We theorized that while students might have liked the process overall, they also recognized an inherent risk with the student-formed approach that enables stronger-willed individuals to push their way onto a project; displacing those who are less motivated. Curiously, the difference went away when students were asked if they thought we should use the same process again, so apparently they felt the risk was worth it: 85% of student-formed and 89% of faculty-formed cohorts agreed we should use their process in the future. We explored these ideas in the focus group discussions (next section).




(Question 9a) (Question 9b)

Figure 10: Team-forming Survey (Is this process equitable? / Should we use it again?)

While we were able to make some high-level observations from the survey results, we felt it was important to speak with students more directly about their approaches and reactions to the team-forming process. As a result, we followed up with focus groups for the student-formed teams.

Student Experience: Team-Forming Focus Groups

To better understand the various team forming approaches used by students in the student-formed cohort, as well how the process influenced students' overall experience when viewed at the end of the project, we conducted two focus groups in May 2019. Each focus group had four students from the student-formed cohort. Unfortunately, due to scheduling constraints, we were unable to conduct focus groups with students from the faculty-formed cohort. The focus groups were conducted by a ent faculty member who is familiar with senior projects but not currently serving as a senior project sponsor or advisor. Each 60-minute focus group was audio recorded and then professionally transcribed to prepare the data for analysis.

During the focus groups, these four questions were posed to the students:

1. Knowing what you know now, would you change the approach you used to select your team or project?
2. In what ways did the team forming experience contribute to your satisfaction with your team?

3. What most affected your overall experience on senior projects – you team, your project, your sponsor, or your advisor?
4. If you were in charge of senior projects, how would you assign teams?

Major themes and illustrative quotes generated from the students' responses to these questions are presented below.

Overall, students were satisfied with the student-formed teaming approach. They felt a sense of satisfaction from finishing a long-term project with teammates who were also friends. Having a friendship in place before starting Senior Projects seems to have contributed to a sense of trust and accountability throughout the project.

> "Socially we're friends, but professionally, as engineering students, we've done projects before. You get a pretty good sense of what other people can do. And as from a friends' point-of-view, you know when they're not doing their work or something, you can read their body language better than if you never met them before. And you're also more willing to help them, too."

> "[Having friends] was like a positive feedback loop because I was willing to invest more time to make sure I didn't let my teammates down."

In terms of strategy, most students described prioritizing teammates over the project. In other words, students preferred to work on a team with people they liked over working on a top-choice project with people they didn't like. Students agreed that they trust their own experience and intuition when it comes to selecting teams, more than they trust faculty's abilities to form teams. They felt that even well-designed surveys that collect information about schedules, preferences, and skills cannot account for the "chemistry" factor – the immediate sense of connection that students may or may not feel for each other – that often contributes to an overall positive team experience. From the students' perspective, the worst possible outcome would have been being teamed with someone they absolutely did not want to work with. Across both focus groups, students agreed that the student-formed teaming approach ensured that this undesirable situation did not occur.

While the students valued having agency to choose their teammates, they were somewhat dissatisfied with the teaming process itself. It seemed to cause significant stress and awkward interactions at the beginning of the course. Students felt rushed having only one class period to form teams, which wasn't enough time to make a well-informed decision. They described going into the team forming class period not knowing how many and whom of their classmates were also interested in their top-choice project.

> "It was definitely stressful trying to fight for the project because I didn't realize how many people wanted the same project I wanted."

This idea of "fighting" for a spot on a project surfaced several times across both focus groups. Beyond feeling rushed, students didn't like how they felt they had to "fight" for their position on a team. This process may have enabled the more extroverted, assertive, and louder students to

secure a spot on their top-choice team, resulting in the more introverted and quieter students to back down from their first-choice project and settle for a project for which they didn't have to engage in uncomfortable conflict. In this way, the student-formed teaming approach may have discouraged more subtle aspects of diversity (i.e. extroversion vs. introversion).

> "It was kind of like, if you're really passionate about it, you should put your life on the line. Kind of explain why you're super passionate about this project, and whoever has the least passion will get removed from the group."

Some students also described that even though they may have been very interested in a project, if they saw a team of four students already standing around the project poster, they felt like an "outsider," too intimidated to approach the group. Perhaps some of this stress could have been alleviated if more time had been given to the team-forming process. Students across both focus groups strongly agreed that more time was needed between when the projects were announced and when they needed to finalize their team choice. They could have used this time to think more about the projects, read about the projects and sponsors online, and – perhaps most importantly – talk to other students who were also interested in their top-choice projects.

> "I think having more time to think about it, and to plan, maybe just talk about it more. And [Senior Project] faculty should definitely talk about it – the process – even to discuss the things that we're discussing right now. Instead of just making it a surprise."

"Slowing down the process can definitely help. Just kind of allowing the process to take a little bit more time so you can think as you're going through. And being notified earlier of the process to have time to start thinking about who we might want to work with and even talking to people you'd like to work with, what they're interested in, and see if your interests coincide."

Student Experience: Team Peer Review Surveys

As an ongoing assessment tool in our capstone courses, students are asked to evaluate each of their teammates throughout the project. These peer review surveys are completed by each student twice per quarter, for a total of six times over the course of the project. The peer review is primarily used as a tool for the faculty instructors to evaluate the extent of individual team member's contributions and the team's functional effectiveness. This survey can also be used to evaluate whether team effectiveness (and by inference, student experiences) was affected by the method of team-forming, by comparing the team feedback data from the two cohorts. Because these surveys are required to be submitted, the response rates were very high, over 90%.

In the peer review survey, students indicated their level of agreement with 15 positive statements about each of their team members. The statements can be grouped into three categories:

Category 1: Team Identity and Mutual Respect. This measure was calculated as the mean level of agreement (over all respondents) with the following statements:

- Contributes to team's success
- Makes others feel valued

- Supports others' ideas
- Treats others with respect
- Enthusiastic about project
- Motivates others to excel
- Encourages others to participate

Category 2: Individual Productivity. This measure was calculated as the mean level of agreement (over all respondents) for the following statements:

- Arrives on-time and prepared
- Actively participates in activities
- Does fair share of tasks
- Completes work on time
- Performs high-quality work
- Uses skills to support team

Category 3: Communication. This measure was calculated as the mean level of agreement (over all respondents) for the following statements:

- Keeps track of progress
- Updates others on progress

Students used a Likert scale (1 = Strongly agree, 2 = Somewhat agree, 3 = Neither agree nor disagree, 4 = Somewhat disagree, 5 = Strongly disagree) to assess how well each of the above statements described each of their teammates. Since all statements describe positive team member characteristic, a score of 1.0 is the 'best' result.

For the purposes of this study, the results were averaged over all students in each cohort, rather than looking at specific teams. In order to make the numerical results easier to interpret, the mean scores were converted to a measure of team satisfaction: Using a linear scale where 1.0 indicates complete (100%) satisfaction and 5.0 indicates no (0%) satisfaction, a *satisfaction* score was created for each cohort in each category. A statistical summary of the peer review data is shown in Table 2.

Table 2: Peer Review Statistics Summary

| | | Faculty-formed | Student-formed |
|---|---|---|---|
| | Sample Size | 470 | 727 |
| 1. Team Identity & Mutual Respect | Mean | 1.2164 | 1.3431 |
| | Std Dev | 0.3795 | 0.4596 |
| | *Satisfaction* | *95%* | *91%* |
| 2. Individual Productivity | Mean | 1.1996 | 1.3184 |
| | Std Dev | 0.4119 | 0.4878 |
| | *Satisfaction* | *95%* | *92%* |
| 3. Communication | Mean | 1.3454 | 1.5066 |
| | Std Dev | 0.5660 | 0.6413 |
| | *Satisfaction* | *91%* | *87%* |

Team satisfaction is high in all three categories for both cohorts. However, in each category, the student-formed cohort has a slightly lower team satisfaction than the faculty-formed cohort. The standard deviation is also higher for the student-formed groups in each case.

Histograms comparing the faculty-formed and student-formed cohorts for each of the three criteria are shown in Figure 11, Figure 12, and Figure 13. In all three, the distribution of scores (1 to 5) is strongly skewed. Most students ranked their teammates with a value of one, for all criteria, for all teaming methods. A value of one is the strongest positive assessment.

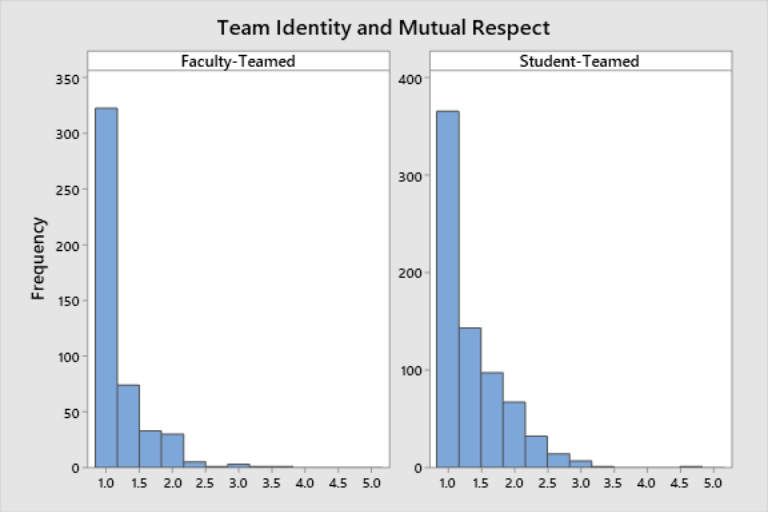



Figure 11: Team feedback for measures of Team Identity and Mutual Respect.
(1: Strong Agreement, 5: Strong Disagreement)

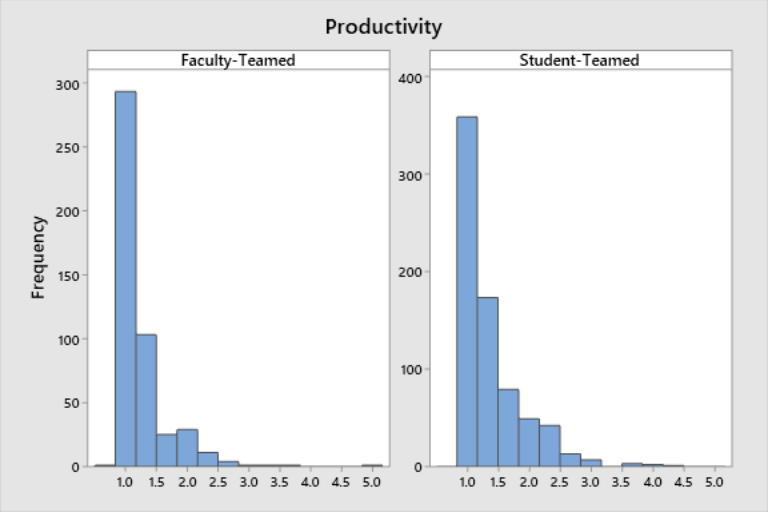



Figure 12: Team Feedback for Measures of Individual Productivity.
(1: Strong Agreement, 5: Strong Disagreement)

To determine if the results are statistically significant, a two-sample T-Test was performed. Results are shown in Table 3. For all three categories, the average assessment is greater (and therefore less positive) for the student-selected teams compared to the faculty-selected teams. Based on the Two-Sample T-Test results, the results are statistically significant for each of the

three categories. The large sample sizes contribute largely to this result. However, the very small confidence intervals in each case indicate that, while the difference is statistically significant, the difference between the groups is still very small.

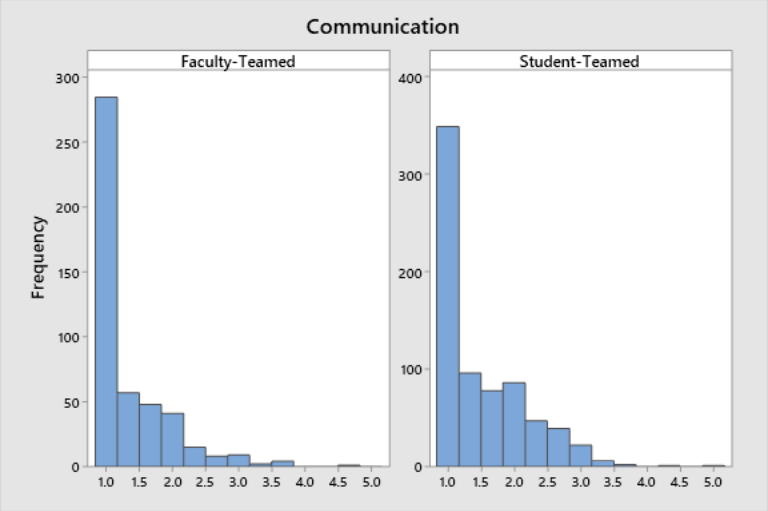



Figure 13: Team Feedback for Measures of Communication.
(1: Strong Agreement, 5: Strong Disagreement)

Table 3: Statistical Significance with Two-Sample T-Test: Faculty-formed teams versus student-formed teams

| Statistical Significance | Team Identity & Mutual Respect | Individual Productivity | Communication |
|---|---|---|---|
| T-Value | 5.18 | 4.53 | 4.57 |
| P-Value | 0.000 | 0.000 | 0.000 |
| 95% Confidence Interval for Difference in Means | (0.079, 0.175) | (.067, 0.170) | (0.092, 0.231) |

These results are consistent with the team satisfaction reported after five weeks into the project. Both are surprising: By giving students the opportunity to meet with other interested students before committing to a project team, they ended up being (slightly) less satisfied with their team throughout the project! Two potential explanations for this effect are that:

(a) Students focused so much on getting the "right" project that they were willing to overlook potential personality conflicts.
(b) Having had some control over their team choice, the students had higher expectations and were therefore more critical of their teammates throughout the project.

Unfortunately, we lack data to determine which, if either, of these explanations are valid. Fortunately, the differences were very small, so it may not be a critical factor when choosing between these two approaches to team-forming.

Student Experience: Overall Course Satisfaction

We considered using the year-end course survey as another measure of student experience. The goal of this survey is to assess course structure and teaching strengths and weaknesses, leading to potential improvements. Like the peer review responses, a comparison of the results between the two cohorts might also be used to gain some insight into the influence of the team-forming process. However, unlike the peer review responses, the faculty instructors likely have a significant impact on the overall student experience (at least, we believe that we have an influence!). Although the class content/structure was the same between the two cohorts, the instructors were different. As a result, we felt it was inappropriate to use overall course satisfaction as a measure for the team-forming approach. As we continue to try different team-forming approaches with the same faculty, we may be able to use this measure in the future.

Faculty Feedback

The faculty teaching team meets often throughout the senior project courses to ensure consistency and address any issues. During these meetings, faculty discussed the team-forming process and on-going team dynamics and project successes. Although not a rigorous assessment, their observations may be helpful to others considering alternatives for team-forming:

- The student-formed teaming process was much less time-consuming for faculty (far less out-of-class time). It was also generally less stressful (less pressure to 'get it right'), although the need to coach/guide students during the in-class team-forming discussions did place additional pressure on the faculty, especially when a team was too large and someone needed to be 'cut.'
- There was no major difference in the faculty perception of team dynamics and project success team interactions between the two cohorts. In fact, both groups of faculty reported that teams seemed to have fewer problems and projects were generally more successful than seen in prior years. This may be the 'placebo' effect since we were focused on it, but we hope it indicates other 'continuous improvement' approaches are having a positive impact!
- Regardless of team-forming method, each cohort experienced some team issues. A 'stress-free' senior project will not be achieved by changing how teams are formed!

Discussion

Due to the size of our senior design program, we have the ability to gather a large amount of data in a relatively short period of time on the influence of different factors on student experience in senior project. In the current study, our focus was on the influence of two types of team-forming on that experience: Faculty-formed and student-formed. Despite the names, both of these approaches give students a lot of input to the process. This is because in our senior design program, each student team works on a different project, and we firmly believe that student interest in the project is a major determinant of project success and positive student experiences.

The data we collected leads to no firm conclusion. Evidence supporting the student-formed teaming process includes:

- A statistically significant increase in the number (52% vs. 29%) of students who were able to work on their first-choice project.
- A statistically significant increase in the number of students (60% vs. 40%) happy to have some control during the team-forming process.
- There was strong support for student-formed teams in the focus group discussions.

There was also evidence indicating some risks with student-formed teams:

- A statistically significant decrease in the number of students (74% vs. 89%) who felt that the team-forming process was equitable.
- A small, but statistically significant, decrease in the average team satisfaction across all categories of the peer reviews.
- During the focus group discussion, there were concerns about students 'fighting' for teams or 'pressuring' others to change.

And, finally, there was evidence indicating no significant difference between the two methods of forming teams:

- After five weeks, over 90% of the students in each cohort were happy with most or all of their teammates (no statistical difference).
- After five weeks, over 80% of the students in each cohort were happy with their project (no statistical difference).
- Over 80% of the students in both cohorts felt that the team-forming process they used should be continued in future quarters.

Despite the mixed results, the data show there are benefits to increasing student agency in team formation, especially for year-long experiences where teams work on different projects. Some of the risks identified in this study, particularly the student concerns about pressure during teaming leading to an inequitable process, may be addressed by implementing minor changes to the in-class team-forming. Our team has implemented some changes to that process for the current year and are gathering data to see if it led to an improvement in this area. There is more work to be done to find the right process, but there is value in moving forward. The focus group feedback, in particular, reinforces strong student support for student-formed teams, provided the process can be improved.

## Conclusions

There are many ways to form student teams for capstone design projects. With a goal of improving project success and student experience by enabling greater student choice and agency in the team-forming process, two different approaches were compared: Faculty-formed and student-formed. While student project and team interests were considered in both cases, students had a much more direct engagement in the team-forming process with the student-formed approach. Both approaches were used in year-long Mechanical Engineering Department senior design project courses. Both of these team-forming approaches were successful in forming teams for the year-long project, and in nearly every case these teams were successful on their projects.

The two approaches were compared based on three main measures: A team-forming process survey conducted a few weeks after project kickoff, six team peer reviews throughout the projects, and focus group discussions at the end of the project. The data from these measures give mixed results: While both the student-formed and faculty-formed teaming processes resulted in high performing teams and positive student experiences, the student-formed process was much more capable at getting students on their top choice project and feeling they had control of the process. Conversely, however, some students felt that the process was not equitable, due to more assertive individuals having a higher influence on the results. In addition, with student-formed teams, peer evaluations were slightly worse throughout the project.

Based on these results, the authors feel that there are sufficient reasons to continue looking for ways to improve student agency in the team-forming process, but the process employed here needs some improvements to avoid the identified risks.

References


1. Barkley, E., et al. Collaborative learning techniques: A handbook for college faculty. John Wiley & Sons, 2014.
2. Agrawal, V. and Jariwala, A. "Web-based Tools for Supporting Student-driven Capstone Design Team Formation." ASEE (2017).
3. Layton, R., et al. "Design and Validation of a Web-Based System for Assigning Members to Teams Using Instructor-Specified Criteria." *Advances in Engineering Education* (2010).
4. Dutson, A., et al. "A review of literature on teaching engineering design through project-oriented capstone courses." *Journal of Engineering Education* 86.1 (1997): 17-28.
5. Aller, B.; Lyth, D.; Mallak, L. "Capstone Project Team Formation: Mingling Increases Performance and Motivation." *Decision Sciences Journal of Innovative Education* 6(2) (2008): 503-507.