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A Discussion and Analysis of Two Methods of Team Selection in an Interdisciplinary Senior Design Program

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INTRODUCTION

Senior design capstone projects are a professional opportunity for students to develop real working solutions for a customer-provided design challenge. During this project-based learning experience, students work closely together in small teams to address the needs of a customer. At our institution, senior design is a three-part course series that takes place over three consecutive 10-week academic quarters. During that time, our students work on interdisciplinary teams to provide solutions for a customer/sponsor need. The number of mechanical engineering (ME), electrical engineering (EE), and computer engineering (CpE) students working on a given design project depends on the project's scope and is determined by the course instructors in consultation with the project sponsors. Team sizes vary depending on project complexity, but commonly are between 4-6 students. After finalizing the required number of ME, EE, and CpE students for each project, the instructors start the team assignment process.

Team selection has been studied in a variety of fields, and while well-functioning teams are critical for project success, the best approach to forming teams remains a topic of discussion [1-4]. Attempts to optimize student project assignments are often based on factors such as student availability [5] and teammate preference [2, 3]. Like many others [5-7], our instructors consider student project and teammate preferences during the team assignment process in hopes that it will increase the likelihood of success, both in delivering design solutions and in creating well-functioning teams. We also consider student availability, which is one of the biggest challenges we face in our program. Our program extends across three academic quarters, which often results in uncontrollable changes to student availability as the projects progress, some of which have significant impacts (e.g., study abroad status). Therefore, the course series structure makes it inherently difficult, if not impossible, to account for student availability when creating team assignments. While student availability is a critical factor for success [5], our program is structured such that availability is an obstacle our students must overcome, rather than a determinant of team assignments.

Instructors in our senior design program have opted to manually optimize team assignments, however there are automated systems designed to handle this task. The CATME Team-Maker system, for example, is a well-known algorithm used to assign student teams based on instructor chosen criteria [5]. Benefits of this system include its automation and adjustability. Instructors have the option to use the criteria already offered and/or create their own, as well as assign a weighting scheme to prioritize certain criteria in generating team assignments or customize a maximum team size. The system also has several limitations however, including uniform distribution of disciplines across teams and student schedules remaining constant for the duration of the project. While other bespoke algorithms for managing variables and optimizing team assignments exist, typically they are not widely available and often they come with their own unique limitations [2, 3, 6, 8], such as requiring that at least one team member has access to a car [2] or using role preferences as the top consideration for team assignments [3]. Regardless of how instructors choose to create teams, team assignments are becoming increasingly difficult, especially with larger class sizes [2]. Giving students their first choice of project and matching them with appropriate teammates is a challenge.

Team dynamics are well-understood to be an important factor for successful senior design projects, yet there are multiple ways to define success in a senior design program. While execution of projects and sponsor satisfaction with student-delivered products are undoubtedly important, fostering an environment that promotes enjoyable, positive student experiences is also critical. Based on one of the author's 30+ years of industry experience working in technology and product design and development teams, team selection is key to success and there are times when associates have an opportunity to choose the projects/people they work on/with and times when they do not. Inevitably, the choice is a mixture and there is a heavy reliance on professional behavior to draw teams together to function effectively and efficiently. This concept prompted the 2023-2024 course instructor to try a new student "self-assigned" team selection process in which students could actively and dynamically participate in the selection process with minimal input and restrictions from the instructor.

To that effect, this work aims to: (1) present a team selection process that, to the knowledge of the authors, is a new approach to team assignments; and (2) analyze data from two student cohorts to explore the relationship between team selection process and overall student

experience. Comparisons of two methods, “instructor-assigned” vs. student “self-assigned,” are made wherever common data is available between the two student cohorts.

We hypothesize that students who are given an opportunity to autonomously choose their projects as part of a transparent, dynamic selection process (i.e., a process in which students can observe their peers’ project choices whilst making their own choice in real time) will experience more enjoyment throughout their capstone experience than students who are assigned to a team by an instructor.

METHODS

In 2022-23, our course instructors employed an “instructor-assigned” method for team assignments. Students were given an opportunity to review descriptions of the projects being offered and complete a Qualtrics survey to share their project and teammate preferences with the instructors. Students indicated their top five project choices and, for their top three, described: (1) why they were interested in and passionate about the project; and (2) what skills, experience, or attitudes they would contribute to a team working on the project. Students also listed up to five students they wanted to work with and up to three students they strongly did not want to work with. To gain insight into student availability, instructors also collected information about study abroad status (i.e., student locations and time zones). The instructors reviewed survey responses, endeavored to manually optimize assignments, and ultimately made informed decisions to create student teams. The instructor-assigned teams were final (i.e., students were not allowed to switch projects).

In 2023-24, the course instructor implemented a student “self-assigned” method to create team assignments. With this new approach, students participated in multiple rounds of a project selection process. During each round, students signed up for their first-choice project in a shared Microsoft Excel spreadsheet provided by instructor. In the shared spreadsheet, students could see their peers’ project selections, academic majors, and study abroad statuses, and could use that information to inform their own project choice. Each selection round was at least 4 hours in duration and students could change their project choice as often as they liked during that time.

Additionally, students could select their first-choice project regardless of the number of available spots.

At the end of each round, students who selected projects that were not oversubscribed (i.e., cases where the number of students who selected a project was less than or equal to the number of spots available) were assigned to their selected project and could not change their selection in subsequent rounds. In cases of oversubscribed projects, (i.e., the number of students who selected a project was greater than the number of spots available), the instructor used a random selection method (coin toss or dice roll) to determine which students would be assigned to the project. Students who were not assigned to their chosen project entered a subsequent round of project selection. This random selection method was communicated to students in advance.

Before the start of the next round, full projects were marked as "closed." The teams assigned to closed projects were finalized and students participating in subsequent rounds of the selection process could not select these projects. The instructor facilitated successive rounds of project selection until all students were assigned to a project. In 2023-24, students completed this project self-selection process in three rounds (Table 1). One student chose to not participate in the self-selection process and the instructor assigned this student to a project after the third round.

Table 1: Self-assigned teams were finalized after three rounds. *One student did not actively participate in the process.

	1st round	2nd round	3rd round
# of students entering the round without a project assignment	61	21	6
# of students exiting the round with a project assignment (% of cohort)	40 (64.5%)	15 (88.7%)	5 (98.4%*)

To identify any inherent differences between the cohorts that might affect our understanding of our results, we compared the distribution of ME, EE, and CpE students, team size, student GPA, team average GPA, and impact of students abroad (Table 2). We found no evidence of significant differences in population means or variances of student GPA (means: $p = 0.36$; variances: $p = .075$) or team GPA (means: $p = 0.48$; variances: $p = 0.85$) with two-tailed independent t-tests and f-tests ($\alpha = 0.05$).

Table 2: Cohort comparison. Team size, student GPA, and team GPA are represented by the mean ± standard deviation. ME = mechanical engineering, EE = electrical engineering, CpE = computer engineering.

	instructor-assigned	**self-assigned**
# of students (ME, EE, CpE distribution)	n=34 (22, 6, 6)	n=61 (36, 13, 12)
# of teams	n=7	n=14
team size	4.86 ± 0.90	4.36 ± 1.01
student GPA (4.00 scale)	3.48 ± 0.44	3.39 ± 0.47
team average GPA (4.00 scale)	3.47 ± 0.23	3.38 ± 0.26
# of students abroad (% of students)	n=6 (17.6%)	n=15 (24.6%)
# of teams with student(s) abroad (% of teams)	n=4 (57.1%)	n=10 (66.7%)

To explore the impact of the two team assignment methods on the student experience, we assessed measures of (1) student satisfaction with assigned projects, (2) student satisfaction with assigned teammates, and (3) overall student enjoyment. To gain insight into how students consider different criteria in their design project selection process, we assessed (4) student prioritization of project vs. teammate preferences (student self-assigned cohort only).

(1) Student Satisfaction with Assigned Projects: To evaluate student satisfaction with assigned projects, we compared students' initial project preferences with their eventual project assignments. For the instructor-assigned cohort, this information was collected in the same initial Qualtrics survey in which students shared their project and teammate preferences with the instructor. For the self-assigned cohort, student selected projects in second and third rounds that did not necessarily correspond to students' second and third project choices. Therefore, the 2023-24 course instructor administered a new online Qualtrics survey in which the self-assigned cohort reported how their initial project preference going into the first round of project selection compared their eventual project assignment. 83.6% of students (51 out of 61) responded to the survey. Within this new survey, the course instructor also asked students to indicate their level of satisfaction with their assigned project, where 5 = extremely satisfied and 1 = extremely dissatisfied. Despite not having available comparison data for the instructor-assigned cohort, the authors chose to present the self-assigned student cohort survey responses to this question in this paper.

(2) Student Satisfaction with Assigned Teammates: CATME peer evaluation data [5, 9] collected in Weeks 5 and 10 out of 30 were used to assess student level of satisfaction with teammates. We compared the prevalence of underperforming team members and of teams with at least one underperforming member. Because underperformance was identified with CATME survey data, this measure reflects students' perceptions of their teammates and not instructor perceptions. Additionally, as part of the new Qualtrics survey that was administered to the self-assigned cohort, students were asked to indicate their level of satisfaction with their teammates, where 5 = extremely satisfied and 1 = extremely dissatisfied. Similar to the measures used for 'student satisfaction with assigned project,' we chose to present the self-assigned student cohort survey data despite not having comparable data for the instructor-assigned cohort.

(3) Overall Student Enjoyment: The course instructors used an online Qualtrics survey to collect student self-reported data to evaluate student enjoyment. Student enjoyment was assessed by level of agreement with the statement "I think the design process is fun" and by level of positivity towards the question "What is your general perception of the design process?", where levels of agreement/positivity were collected on a 5-point Likert scale (1 = strongly disagree/negative; 5 = strongly agree/positive).

(4) Student prioritization of project vs. teammate preferences (self-assigned cohort only): After completion of the team selection process, the instructor asked students to indicate how they weighted project and teammate preferences in their project selections. Data were captured on a 5-point scale, where 5 = project most important and 1 = teammates most important. Because students in the instructor-assigned cohort did not actively interact with the instructors during the team assignment process, they could not prioritize project and teammates preferences during that process. Therefore, there is no comparable data measure for the instructor-assigned cohort.

RESULTS

(1) Student Satisfaction with Assigned Projects: In a comparison of initial project preference and eventual project assignment, 30 out of 34 students in the instructor-assigned cohort (88.2%) were assigned to one of their top three project choices while 51 out of 61 students (83.6%) in the self-assigned cohort worked on one of their initial top three project choices (Table 4).

Table 4: Eventual project assignments in comparison to initial project choices.

	number of students (% of cohort) assigned to…				
	1st choice	**2nd choice**	**3rd choice**	**other choice**	**data not available**
instructor-assigned (34 students)	16 (47%)	9 (26%)	5 (15%)	4 (12%)	0 (0%)
self-assigned (61 students)	40 (66%)	8 (13%)	3 (5%)	8 (13%)	2 (3%)

Survey data indicate that, on average, students in the self-assigned cohort were somewhat satisfied with their project choice (average satisfaction level = 4.08), with 88.2% of students (45 out of 51) reporting at least neutral and 80.4% of students (41 out of 51) reporting somewhat to extreme satisfaction. The full distribution of survey responses is shown in Table 5. Since these data were collected with a newly developed survey, similar data are not available for the instructor-assigned cohort.

Table 5: Distribution of survey data capturing student satisfaction with assigned teammates and assigned projects.

Satisfaction level…	**…with design project**	**…with teammates**
Extremely satisfied (5)	20	26
Somewhat satisfied (4)	21	18
Neither satisfied nor dissatisfied (3)	4	5
Somewhat dissatisfied (2)	6	2
Extremely dissatisfied (1)	0	0
Unknown (student did not provide a survey response)	10	10

(2) Student Satisfaction with Assigned Teammates: CATME data collected at Week 5 out of 30 revealed that 6 out of 7 instructor-assigned teams (86%) and 2 out of 14 student self-assigned teams (14%) identified at least one underperforming team member. At Week 10 out of 30,

there was no change in the number of instructor-assigned teams affected by underperforming team member, but there was an increased prevalence of underperformance in the student self-assigned teams (8 out of 14 teams, 57%). The prevalence of underperforming students at Week 10, as identified by CATME data, showed a similar trend (Table 6).

Table 6: Prevalence of underperforming students and teams with at least 1 underperforming student at mid-quarter and end of quarter evaluations. Underperformance was defined according to CATME peer evaluations.

Cohort (# of students, # of teams)	**number (%) of underperforming students**		**number (%) of teams affected by underperforming students**	
	Week 5 of 30	*Week 10 of 30*	*Week 5 of 30*	*Week 10 of 30*
instructor-assigned (34 students, 7 teams)	9 (26%)	11 (32%)	6 (86%)	6 (86%)
self-assigned (61 students, 14 teams)	2 (3%)	11 (18%)	2 (14%)	8 (57%)

Additional Qualtrics survey data showed that, on average, students in the self-assigned cohort were more than somewhat satisfied with their teammates (average satisfaction level = 4.33) (Table 5). 86.3% of students (44 out of 51) reported they were somewhat to extremely satisfied with their teammates and 96.1% of students (49 out of 51) reported they were at least neutral in their level of satisfaction (Table 5). As previously indicated, these data were collected with a newly developed survey and therefore similar data are not available for the instructor-assigned cohort.

(3) Overall Student Enjoyment: The student mindset of both cohorts trended towards agreement with the statement "I think the design process is fun," as well as towards a positive perception of the design process (Table 7).

Table 7. Survey results of student perception of the senior design experience. Responses were captured on a 5-point Likert agreement scale (1 = strongly disagree/negative, 5 = strongly agree/positive).

	Instructor-Assigned		Self-Assigned	
	mean ± SD	# of responses	mean ± SD	# of responses
I think the design process is fun.	3.38 ± 1.60	8	4.35 ± 0.81	20

What is your general perception of the design process?	4.12 ± 1.46	8	4.15 ± 0.81	20

(4) Student prioritization of project vs. teammate preferences: Students in the self-assigned cohort tended to prioritize projects over teammate preferences (average prioritization = 3.82). 60.8% of students (31 out of 51) prioritized project preferences over teammate preferences. In comparison, only 7.8% of students (4 out of 51) prioritized teammate preference. The distribution of survey responses is shown in Table 8.

Table 8: Distribution of survey data capturing student prioritization of project vs. teammate preferences.

Selection Priority	**Count**
Project most important (5)	16
Project slightly more important (4)	15
Project & teammates equally important (3)	16
Teammates slightly more important (2)	3
Teammates most important (1)	1
Unknown (student did not provide a survey response)	10

DISCUSSION

This paper presents a new approach to assigning teams in a senior design course and aims to gain a better understanding of the relationship between team selection process and overall student experience. We describe our implementation of a student "self-assigned" team selection process that relies on the students to engage with the team assignment process. With this approach, students have an opportunity to consider their project and teammate preferences during the selection process and make real-time decisions and adjustments based on their priorities. In contrast, the more traditional "instructor-assigned" team selection process relies on instructors to collect pertinent information (e.g., project and teammate preferences, student availability) and make informed decisions on team assignments. This method enables instructors to place higher consideration on GPA, academic performance, prior experiences with the students, etc. and, as a result, outcomes may be influenced by instructor biases. Another limitation of this approach is that it is often extremely time intensive for course instructors [6, 4, 10].

Much like the instructor-assigned approach assumes an "instructor knows best" mindset, the "self-assigned" approach assumes a "let the students decide what is best" mindset. While the self-assigned method may eliminate the impact of instructor bias, it could create other boundaries and introduce other forms of bias from the students, a concept that should be studied in further detail if this method is used in future.

Our initial data suggest that students have a similar experience regardless of how their teams are selected. They may choose unsustainable work practices in the process [11], but these can be difficult to capture. When considering student satisfaction with assigned projects, our results indicate that roughly the same percentage of students in each cohort were assigned to one of their top three project choices, regardless of the method of project selection. With both selection methods, 16% of the students were neutral or less than satisfied with their project, corresponding to 13% of students working on a project that was not among their top two choices. Interestingly, despite 63% of the students in the self-assigned cohort being assigned to their first choice of project, only 39% were extremely satisfied with their project selection after the completion of the first quarter of their project. This finding supports the notion that student satisfaction with assigned projects is complex and can be influenced by a variety of factors.

The number of underperforming students increased in both cohorts as the course progressed, but the increase was greater in the self-assigned cohort. Perhaps these students took longer to publicly identify underperforming members because they had to overcome the fact that they had selected their projects/teammates instead of being assigned to them. This outcome might also suggest that students eventually come to realize that no corrective action can be taken if underperformance is not brought to the instructor's attention. Interestingly, 86.3% of students (44 out of 51) in the self-assigned cohort indicated they were somewhat to extremely satisfied with their teammates despite the high likelihood that at least some of those students were on teams with underperforming teammates.

Our students indicated that project preference was a more important consideration than teammate preference when selecting their projects during the team assignment process. This finding aligns with that of Watkins, who observed this same mindset in 72.5% of their students [3] and suggests that while teammate preference is important it may not be the most important factor to consider when forming team assignments.

The work presented here focused on a student self-assigned approach, and it would be interesting to explore methods that combine instructor-assigned and student-self-assigned approaches and promote instructor-student (and potentially sponsor) collaborations in the future. One foreseeable challenge we see to this collaborative approach in our academic system is the time requirement for instructor-student collaboration. Assigning teams efficiently is critical for our senior design program, as the quarter system is already challenging for project schedules. Our instructors finalize team assignments prior to the start of the year so that students can schedule and prepare for sponsor meetings within the first two weeks of the quarter, which accounts for 20% of the time available to them before winter break. This time constraint makes it difficult to involve a lot of consultation between students and instructors (and potentially sponsors).

The relationships between team selection methods and student experience are applicable not only to Senior Design, but to any course where teamwork is required. Our results seem to suggest that the exact method of team selection does not matter so much as the students having an opportunity to vocalize their preferences as part of the team selection process. This opportunity is likely a more important factor than the precise method of team assignment. A longer-term prospective study could perhaps be more definitive on the topic. However, if students enjoy their senior design experience and gain some valuable professional application of learning solving customer defined problems then perhaps, we have prepared them to be valuable contributors to the working world.

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