

Improving the Student Experience in First Year Engineering Design Courses

James R McCusker PhD, Wentworth Institute of Technology

James R. McCusker is an Associate Professor at Wentworth Institute of Technology in the Department of Electrical Engineering. Since joining Wentworth in 2010, he has been heavily involved with an array of interdisciplinary design courses that range from introductory to capstone courses.

Prof. Aaron Carpenter, Wentworth Institute of Technology

Professor Carpenter is an Assistant Professor of Electrical Engineering at Wentworth Institute of Technology. In 2012, he completed his PhD at the University of Rochester in the field of computer architecture. His research interests focus on computer engineering, computer architecture, digital systems, cybersecurity, and engineering education.

Prof. Julian Sosnik PhD, Wentworth Institute of Technology

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James R. McCusker, Aaron Carpenter, and Julian Sosnik

Wentworth Institute of Technology, mccuskerj@wit.edu, carpentera1@wit.edu, sosnikj@wit.edu

Abstract - First Year Design courses are commonplace in many engineering curriculums. Although the focus of these courses typically revolves around introducing students to various multistep design processes as well as improving student skills in written and oral communication techniques; they can be limited in replicating the experience of working in a real world interdisciplinary design environment. In an industrial setting, design teams are comprised of members that have the complementary skills that are necessary to complete the relevant task. There are many tools, like Team-Maker CATME, available to replicate this process of designing student teams based on complementary skills. Prior studies have illustrated that, although assigned teams can improve the experience for some, it can also drastically diminish the student experience for others. This work focuses on the assignment of student design teams based on both complementary skills, as well as shared interests.

Index Terms – Design, Interdisciplinary, Student Experience, Teamwork

INTRODUCTION

Engineering Education requires that sufficient attention be placed on simulating a realistic work environment to adequately prepare students for their careers. A significant part of this is in the preparation of students to work in varied design environments that often require working in teams comprised of individuals with diverse skills and background [1]. The opportunity to develop the skills necessary to work in this type of environment can be addressed early in an engineering curriculum through first year engineering design courses.

First year design courses are a common component of many engineering curriculums. Although the format of these courses can vary drastically, a common component of many is in working on design projects with a team comprised of their peers. Although there is an array of approaches that can be utilized to form student teams, replicating the interdisciplinary design environment that students may experience post-graduation can be achieved through assigned teams based on complementary skills [2,3].

While research shows that the various methods of assigning student teams can be instrumental in developing student skills [4], they can also have positive and adverse

effects on the overall student experience [5]. In first year engineering education, the overall student experience relates directly to student retention [6]. Therefore, it is imperative that, while maintaining an authentic design experience, attention is also made to provide a positive student experience.

This study focuses on how, while considering the unique circumstances of academic teams, intelligently designing student teams can both replicate the challenges of an interdisciplinary design environment and improve the overall student experience.

FIRST YEAR DESIGN

The College of Engineering and Technology at Wentworth Institute of Technology in Boston, MA is comprised of 7 Engineering majors for whom approximately 550 first year engineering students enroll annually. Starting in 2015, the course Introduction to Engineering Design (ENGR1500) became a required course for all first year engineering students. As a required course in a common first year curriculum for Biomedical, Civil, Computer, Electrical, Electromechanical, Interdisciplinary and Mechanical Engineering majors, annual enrollment in ENGR1500 exceeds 500 students [7].

The course is comprised of one hour of lecture and four hours of laboratory per week. Through a series of modifications to the overall course structure since 2011, the course has evolved into the current project-based format. The details of the evolution of this course, along with the detailed description of the course content, lab structure, and design projects, can be reviewed in [7].

Despite the fact that ENGR1500 is comprised of students from seven different engineering majors, organizing an authentic representation of an interdisciplinary design environment has proven to be challenging for first year students. This is compounded by the fact that the Wentworth Institute of Technology has also adopted a common first year engineering curriculum in the 2015/2016 academic year. As a result, there is little difference between students enrolled in the course, regardless of their chosen major. This work studies three years of data on the impact of assigned groups in these courses, as they pertain to overall student experience.

TEAM FORMATION

To address the limitation in organizing student teams based solely on their chosen discipline, a study of the merits of a skills-based assigned team approach was conducted in 2016 [10]. For this, although the Team-Maker component of CATME could be used to automate the process, students completed a student profile at the beginning of the semester that was utilized for group assignments. This profile worksheet is illustrated in Fig. 1.

ENGR1500 Student profile					
Name: _____					
Major: _____					
Commuter: Yes/No (circle one)					
Expertise:					
Topic	Level of expertise (Circle one: 5- Expert to 1-no exposure)				
Research	1	2	3	4	5
Manufacturing	1	2	3	4	5
Team management	1	2	3	4	5
Solidworks	1	2	3	4	5
MATLAB	1	2	3	4	5
Electronics	1	2	3	4	5
Biomechanics	1	2	3	4	5
Technical Communications	1	2	3	4	5
Soil Mechanics	1	2	3	4	5
Other: _____	1	2	3	4	5
Other: _____	1	2	3	4	5
Other: _____	1	2	3	4	5

FIGURE 1
STUDENT PROFILE WORKSHEET

Using the completed worksheets, the instructor assigns student teams to diversify the skillset of the team members. Once teams are assigned, the student design teams begin the development of their semester long design project [7]. For this, they identify a loosely defined societal need and engage in the five-step design process described by G. Voland in [8]. At the conclusion of the semester, students present their designed solutions along with its evaluation at the First-Year Design Showcase.

In 2016, although many of the students in the assigned team groups indicated an overall positive experience with the course, there was a significant portion that indicated a poor experience, stemming from the makeup of their student team. The following student response is an instance of conflict based on the makeup of an assigned group:

'In the real world, where we'll be hired to do work like this, all the members will have been picked specifically for the task at hand, and therefore will be better suited to work in a team to achieve their goal. In the classroom, people are randomly placed into a section, and it's a real crapshoot to figure out who wants to get things done and who's just taking the course because it's required. It's a very different dynamic and should be acknowledged.'

This feedback motivated additional modifications to the group assignment procedure. It was identified that projects that were more successful were a result of a shared interest among a majority of the group members. In groups that produced negative experiences, it was common for there to be limited or no shared interest in the selected project. In 2017, students were assigned using the student profile sheet shown in Fig. 1 in addition to an inquiry of student interests. Although Team-Maker could be used for the collection of student information, the open-ended aspect of the student interest inquiry motivated the use of a modified Student profile worksheet for group assignments. Using the modified student profile sheet, groups were assigned using the procedure addressed in [9] with a priority placed on assigning the groups with a shared interest.

ASSESSMENT PROCEDURE

In order to assess the merits of the various group assignment procedures over three years of the course, various sections adopted one of the following structures for group assignments: 1) student selected (select sections in 2015 iteration of ENGR1500), 2) skills-based instructor assigned (select sections in 2016 iteration of ENGR1500), 3) skills and student interest based instructor assigned (select sections in 2017 iteration of ENGR1500). Written feedback and peer assessment based on ABET Outcome D - ability to function in multidisciplinary teams - were collected from the students. Our analysis of this data focuses on the process of intelligently assigning student groups and the techniques that can improve the overall student experience.

Quantitative assessment was performed using a structured peer assessment procedure. Peer assessment was performed by each student of their groupmates. Each student assessed their peers on a scale of 1-4 (1 lowest and 4 highest) using the following criteria and a provided assessment rubric:

- Ability to collaborate towards a common goal
- Ability to fulfill team duties and responsibilities

In the peer assessment, students were also encouraged to provide general feedback on their peers regarding their performance in order to provide added insight into the positive and negative experiences.

Qualitative assessment was also performed using a general survey of the students experience in their groups and the course in general. In this survey, students addressed the following questions:

- How well did your group function on the project?
- Provide comments related to the course (what you liked, what you did not like, comments to be considered for the future iterations of the course, etc.)

RESULTS

Peer assessment produced some insight into the overall student experience though the lenses of the groupmates that worked together throughout the semester. The average value of the peer assessments for all student for both outlined criteria is illustrated in Fig. 2.

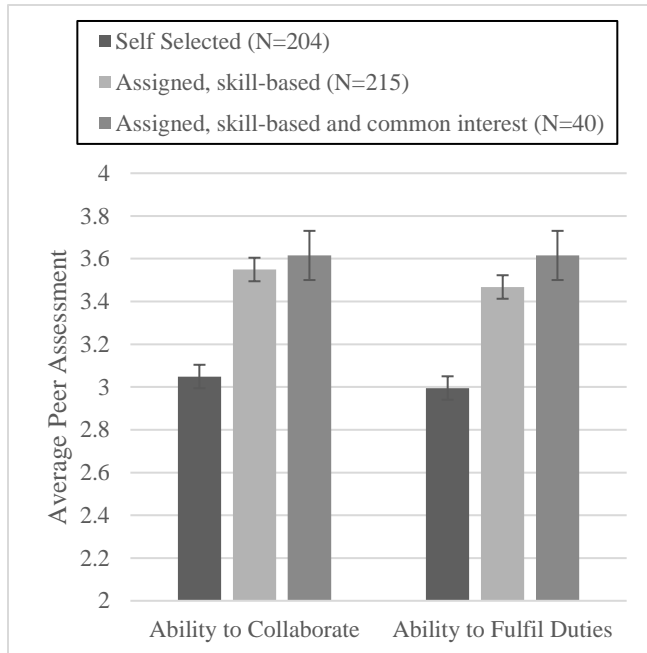


FIGURE 2
PEER ASSESSMENT RESULTS (±STANDARD ERROR)

Figure 2 illustrates that there was a marked improvement for both criteria in assigned groups over that of self-selected. There was also a slight improvement in both criteria, although not statistically significant (probably due to a smaller sample size), in assigned groups when students shared a common interest. The results of the assessment for the ability to fulfil duties illustrates that assigned groups may not be as effective if a common interest is not shared among the groupmates.

Student survey results fell into two categories for assigned groups. Overall positive experience and overall negative experience. Examples of positive responses for assigned teams include the following:

“My team worked really well with each other. If one of us didn't know the answer or didn't understand a certain part someone in the group would explain it. We would assign certain part to each individual and we would have it done by the time we said we needed to have it done by. We were able to work perfectly fine with each other with no problems. I don't feel that one of us has slacked off on any work at all. We always have people re-reading each other's work and making small edits to it so it's all well written. All my teammates are great to work with and if possible will work with them in the future.”

“Our team was well-organized when it came to this project. We met multiple times for this project. We all did our parts on time and was manage [sic] to complete everything on time. As a team we came up with many ideas on how the prototype should look and we all contributed on how it would function.”

“This was the best team I have ever worked with”

In contrast to the positive responses, there were also a number of students that viewed the assigned groups in a negative light. The following are examples of these responses:

“At first we had trouble getting along, people expected others to do the work and decided to slack off. Some didn't even make an attempt to make it to the out of class work sessions. Team worked together most when we were pressured for time which I did not appreciate so I did the most of the work separately. I kept noticing a pattern of teammates doing the bare minimum on assignments”

“I feel as if the team was average. One thing that I noticed was that there was no incentive or motivation to complete the project. For example, when there was time in class to work on the project, the rest of my group saw it as time to do nothing. That is very discouraging because I feel as if I have no backup and makes me want to do nothing as well. Besides that, we seemed to be fairly organized and got everything that we needed to done.”

“The course would be better if students got to pick their groups”.

Although the negative responses were indicative of the experience for a number of students that had assigned student teams, there was a slight drop in the amount of negative experiences when groups were comprised of members with common interests (Table 1).

TABLE I
NEGATIVE EXPERIENCES

Assigned Team structure	% Negative Response
Skill-based	20%
Skill-based and common interest	15%

DISCUSSION

The quantitative assessment indicated that intelligently assigned groups can have a positive effect on the overall student experience, however a common interest produces a more consistent experience. Student engagement in a project that does not interest all members of a group can produce a significant drop in the student experience over that of self-selected groups.

It can also be noted that the number of students that voiced a negative experience with the class overall, can drop

when a common interest is shared among groupmates. However, with 15% of students still indicating an overall negative experience with the course as a function of the makeup of their group, future investigation is required to identify a preferred methodology for structuring design teams that can simulate the interdisciplinary makeup of industry design teams.

One notable observation that was made for assigned design teams is that student personalities influenced the quality of the experience. In certain instances, an entire design team would be comprised entirely of students that could be described as introverts. An example of this can be seen in the following survey response:

“Although our group was pretty quiet and didn't communicate as much as we maybe should have, I feel we still efficiently accomplished our goal and were all on the same page throughout the project. Progress was consistently made each class period, and we remained on track throughout the semester (for the most part).”

Although this did not produce an overall negative response, it did hinder the experience of the students and could be used as motivation for an additional component in an assigned team structure.

One additional observation is in the structure that was utilized in a single section of the course that was not included in this study. This section took a hybrid approach that broke the project into two parts and structured the teams differently for both parts. The first part utilized large skills based team assignment (6-9 members) and revolved around a top-level design that was very broad in nature. Once the overall design was formulated, specific components or process that required development to complete the design were identified by the group. At this point, the group broke up into small self-selected groups to develop the prescribed components or processes. At the conclusion of the project, these groups produced very high-quality designs and also identified an overwhelmingly positive experience. Although their experience was not included in the above assessment, this may provide an attractive alternative model for future iterations of the course.

FUTURE STUDIES

Although the promise of intelligently assigned teams that include shared interest presents promise in providing an overall positive experience for students, further modification to the process is required. In subsequent iterations of the course, two additional methods are planned.

- 1) Skills-based assigned teams that includes consideration for complementary personalities through a preliminary personality test.
- 2) A Hybrid approach that assigns large teams for a top-level design then allows for self-selection for detailed design work.

In regard to the former method, common personality tests are not an uncommon tool for group formation or group development [10,11]. Students in these courses take the Kolb [12] and/or MBTI [13], or other personality classification tests, and then those tests can be used to pair complementary skills and tendencies or help students gain insight into their own typical behaviors, strengths, and weaknesses. Kolb classifies people into the styles of: accommodating, diverging, assimilating, and converging, while MBTI describes extrovert/introvert, sensing/intuitive, thinking/feeling, and judging/perceiving. Each category has particular traits and tendencies, all impacting the learning styles and team characteristics and roles.

In the proposed methods, students will take personality tests, including both Kolb and MBTI, and this will form partial criteria for group formation. In groups of 3-4, students could be grouped with both complementary and self-similar personalities, in an effort to understand what matches are most effective for (a) project success and (b) student satisfaction. Personal interests and technical skills will also be considered in addition to considering methods to foster an environment of psychological safety [14], to improve the overall student experience.

For the second proposed methodology (hybrid approach), an expansion of the experience piloted on 2017 will be applied in 4 to 8 sections, in order to obtain a significant quantitative assessment of the results. One of the aspects that makes this approach a positive experience, concerns the student's attitude towards the project. By simply acknowledging that self-election will follow from the original assignment of the groups, the student's ownership on the group is higher than in simple affiliation by assignment. A tool to measure the change in attitude is being formulated and will be used in the assessment of the application of this methodology.

These two approaches will be explored and implemented into select sections of the 2018 iteration of ENGR1500 and will be the subject for future studies.

CONCLUSION

Intelligently designed student teams can produce a more realistic simulation of an interdisciplinary design environment. However, if done without consideration for a shared interest, assigned student teams can be detrimental on the overall student experience. In addition, observations lead the authors to believe that complementary personalities must also be considered in order to further improve upon the student experience.

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AUTHOR INFORMATION

James McCusker, Associate Professor, H.C. Lord Chair Professor, Department of Electrical Engineering, Wentworth Institute of Technology, mccuskerj@wit.edu

Aaron Carpenter, Assistant Professor, Department of Electrical Engineering, Wentworth Institute of Technology, carpentera1@wit.edu

Julian Sosnik, Assistant Professor, Department of Interdisciplinary Engineering, Wentworth Institute of Technology, sosnikj@wit.edu