ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022
Paper ID #37953

Work In Progress: Implementing Team Projects in Online Courses - Balancing Individual Responsibility and Team Collaboration

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Abstract

This Work in Progress paper will describe a structure for online projects and a team formation process to address some of the challenges in implementing design projects for teams of online students. These challenges include time zone differences, scheduling constraints for virtual meetings, varying levels of backgrounds and motivation, and team membership changes due to students withdrawing from class.

In an attempt to address these challenges in the online Introduction to Engineering course, offered at Arizona State University, a 'robotic swarm project' was developed and implemented, which involves each team member designing an individual mobile robot with a specific function and the team coordinating their robots together to accomplish a collective task of their choice. This project balances team collaboration and coordination with individual responsibilities and its modular nature also makes it easy to implement for team members not located in the same place or time zone. In this paper, the details of this project and how it helps overcome the online teamwork challenges will be discussed. We will also describe a team formation process, where students are allowed to select their own teams and have control over the membership as the project progresses. Plans for future work to assess the efficacy of this project structure and team formation process will be discussed as well.

Introduction

Teamwork is an important part of engineering and an integral part of project-based learning. While incorporating team projects in face-to-face engineering courses is commonplace, implementing a team project in an online course has its own unique challenges [1]. One obvious difficulty is collaborating on a project whose components are handled by students in different physical locations. Furthermore, online students often belong to a non-traditional demographic. They often have scheduling constraints due to a full time job, family, etc. Students often come with varying degrees of background knowledge, gaps/hiatuses in the educational timeline, and different levels of motivations. Teams can easily suffer from a lack of timely communication for various reasons. In addition, team membership may change at any point of the course due to students dropping the class because of their unique constraints.

Many of these challenges have been observed in the online Introduction to Engineering course that is offered to students in the online degree programs at Arizona State University. It is a

2-credit course taught in 7.5 week sessions asynchronously using pre-recorded video lectures, individual activities/assignments, quizzes, and team design projects. This course introduces the engineering design process and provides students with opportunities to apply it in real world settings. It also focuses on both technical and non-technical skills that are important to set the students up for success in their engineering, academic, and professional careers.

Working in a team environment is a major part of the course and an important course objective. Our previous experiences suggest that when a student has a negative team experience, their learning, as well as attitude towards the course and even engineering in general, may be negatively impacted. It is inevitable that team conflicts and other issues may occur in any team environment, and being able to work through the conflicts and issues is an important teamwork skill. Additionally, working in an online team environment poses some unique challenges, often due to time zone differences, team member disengagement, balancing work, family and school, etc. These challenges may be minimized with a properly designed structure for the course, project, and teamwork. This paper showcases our approach to minimize these challenges and provide a positive team experience in our online Introduction to Engineering course.

Methods and Approach

The centerpiece of our 7.5 week long, Introduction to Engineering course is the team based design project. In this section, we describe the two most important aspects of our approach, the team project implementation and team selection. The course timeline showing how these are embedded is as follows:

- **Week 1**: Students learn about the Engineering Design Process, and begin applying it in a short, open-ended, *individual project*. They also start looking for team members for the final *team project*.
- **Week 2**: Students learn about CAD and oral technical communication. They use both of these to showcase the product they designed for their *individual project*. At the end of this week, students will have chosen (or are assigned by default) a team for the final *team project*.
- **Week 3**: Students learn about electrical fundamentals, Arduino, sensors, and actuators. These topics are relevant to their *team project.* Students also finalize the team membership during this week and start working on the *team project.*
- **Week 4**: Students learn about project management and written technical communication. They submit a short report (problem statement) informing instructors about the *team project* topic they chose and then they submit a detailed proposal report that describes a design solution to the identified problem.
- **Week 5**: Students learn about programming in Arduino and MATLAB, and keep working on the implementation of their proposed design solution for their *team project*.

- **Week 6**: Students further learn about MATLAB relevant to their *team project*. They also learn about grand challenges in engineering as a general topic.
- **Week 7-7.5**: By the end of this week, students showcase their *team project* as a short video.

Team project

To overcome the challenges described in the previous section we chose the focus area for the team project to have the following features: 1) it should be easy to divide tasks among team members in a uniform and fair way and there should be an appropriate balance between individual and team tasks; 2) within the focus area, the team has freedom to choose the exact topic based on their interests and motivation; 3) if a team member drops the course, the project can still continue; 4) the project should allow for interdisciplinary collaboration between students of different majors such as mechanical, electrical, and software engineering; 5) students should be able to complete the project with minimal need for materials, if they have any difficulty procuring them.

The project focus area we chose was ‘robotic swarms’. The robotic and automation theme makes it ideal for interdisciplinary teams of various engineering majors. Team members will collectively choose a complex task of interest that can be accomplished by a collection/swarm of simple robots where each individual robot is designed to accomplish a unique task. For example, a team can create a collection of robots to contain a wildfire where each individual robot would have a task like detecting the fire or human casualties, safely transporting the survivors, containing the fire, etc. Other examples include a collection of robots to service a car, clean a house, manage a farm, etc. Each team member designs an individual mobile robot with a specific function, and then the ‘team’ of robots will coordinate together to accomplish the overall task.

Thus, this project balances team collaboration along with clearly defined individual responsibilities. Since each person creates an individual robot, the work and learning objectives are fairly and evenly divided among the team members. The project is highly modular, making it easy to implement for team members not located in the same place. Each teammate designs a separate robot, making it simpler to distribute the workload and meet technical course objectives uniformly. It is also easier to handle changes in team membership during the course because individual robots come together to perform the overall task only toward the end of the project. Also, the team project starts around week 4 instead of week 1 so class enrollment is already more stable.

The team project description provided to the students at the start mentions some constraints, e.g., how complex their project can be, minimal requirements for sensors, actuators, coding, etc. This is to ensure consistency in efforts and similarity in the level of difficulty across various teams in the class. This way the grading rubrics can be fairly applied to all the teams. Since students have a choice regarding the exact topic of the team project, the resulting open-endedness improves motivation and the students often theme their projects based on their interests, problems, or current jobs. Over the semesters, students have amazed us with the wide variety of project topics from sewer-cleaning robots to asteroid-mining robots.

Students have an option to design their individual robots using physical parts (sensors, actuators, microcontrollers etc. from a recommended kit) or design in simulation (using CAD, circuit simulators, etc.), thus offering enough flexibility for online students. In this way, various aspects of this project structure make it robust to many of the online team challenges described previously. Parallel to the project, students have lectures and individual assignments where they learn the technical and non-technical skills necessary to complete project deliverables, as described in the timeline above.

While the students can work on their individual robots separately, demonstrating their collective behavior is a challenge for online students located at different places. Currently, we have developed a MATLAB-based robot simulator. Students create robust rules regarding how the information will be shared between the robots to accomplish the collective task. They code these rules into the provided MATLAB script template which simulates the 2D motion of multiple robots. This simulation is a part of their final project showcase. Students have the option of shipping all their robots to a designated team member to demonstrate the collective task, if they chose to design their individual robots using physical parts, though this option has not yet been used.

Team selection and management

Similar to the project topic, we also offer a choice and flexibility in the team formation. At the beginning of the course (week 1), students post their 'resume style' information (name, contact information, skills/strengths, schedules and constraints, time zones, project topics of interests, etc.) to a public spreadsheet. The students are then given a 'recruitment period' to contact and interview potential team members for their project. Many of the assignments during week 1 and week 2 involve submissions on the discussion boards. This gives an opportunity for students to showcase their skills and view others' work prior to team selection. Thus, the students organically form teams of 3 or 4 students. As per our observation, teams are often formed based on common interests, skill-diversity and overlapping schedule. At the end of the recruitment period, the course instructor may form the teams for the remaining students (usually only a few). Our approach to team formation is a combination of the common methods of team formation found in the literature, i.e., random, student choice, aspirational, availability, previous achievements, and different skills and knowledge [2].

After forming teams, students develop (as part of a 'team norms' assignment) very specific rules for team management, individual roles, expected quality of work, communication, conflict resolution, providing feedback, etc. They learn about various team formation and teamwork principles (e.g., Tuckman's model of team development [3] and the GRPI model [4]) and incorporate them in the team norms. By setting the expectations early on, the team norms help reduce potential team issues. They also form a starting point for conflict resolution, if instructors get involved.

Another aspect of our team management principle is that students are allowed to change their membership at any time with due process (e.g., one week notice and instructor involvement). Despite the option of removing a team member from the team, this feature has rarely been invoked by the students over the many semesters this course has run. We use peer evaluations as an important way to ensure that team members are cognizant of their role and contributions in a healthy team. There is a peer evaluation in the middle of the team project, where each team member rates others and provides constructive feedback. Then, there is a similar peer evaluation at the conclusion of the project. Peer evaluations affect the individual grades despite the overall team score.

The flexibility of choosing the project topic in a specially designed focus area (swarm robotics) and the flexibility in choosing, managing and (potentially) changing the team have been the central features of our approach to improve the team experience in an online course.

Expected Results and Discussion

We are in the process of collecting the data to measure the effectiveness of our approach, especially its effect on the individual experience, team experience, and student motivation as measured through various survey instruments and frameworks e.g., the Team CARE model and assessment tool [5] - [6]. We'll also use peer evaluations, assignment scores, and course feedback to measure the effects of our approach. Nevertheless, early evidence has provided us with some encouraging results.

The project focus area and especially the choice offered in the project topic, has brought a lot of positive feedback in the course evaluations. Students have expressed appreciation for the skills acquired in the CAD and automation using Arduino. The improved student motivation is clearly reflected in the choice of their project topics. By choosing robotic swarms which are related to their household tasks (e.g., cleaning) or professional jobs (e.g., car service) students are exhibiting their ability to make connections between what they learn in the course and what they observe outside.

The number of reported team conflicts has markedly reduced since the introduction of this new team formation approach (as opposed to earlier approach where instructors assigned the teams based on collecting relevant data). As expected, the students who are more diligent and 'on task' tend to form teams earlier on and have a positive experience. They are less likely to feel that they are pulling more than their fair share of the weight. However, the most interesting observation was that even the students who 'didn't get picked first' or were assigned the teams at the end by the instructor, performed well in their teams. A possible explanation for that is that in such teams students feel an increased need to step up to their role. Shifting the power of team formation from the instructor to the students seems to increase the individual accountability and a sense of responsibility among the students towards their team. They are more likely to take ownership of their team tasks.

Besides measuring the effectiveness in a quantitative way in the upcoming courses, other areas of future work include improving the MATLAB simulator for testing the inter-robot collaboration. We want to make it simpler to use (less coding-intensive) and have better graphics and physics simulation, similar to some recent work [7].

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