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Work in Progress: The Incorporation of Hands-On, Team-Based Design Challenges in a Large Enrollment Introductory Biomedical Engineering Course

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Introduction

The integration of engineering design experiences in first year undergraduate courses have been widely reported and considered to be a valuable experience for students[1-3]. One objective for hands-on design experiences is building team-based problem solving skills, in which students gain experience balancing their own contributions with that of their team members[2]. Numerous courses have incorporated teamwork as an outcome for students, in which project and/or time management serve as two related keywords[4]. Inherent in teamwork experiences must also be some level of organization, in which a process or method may be utilized to accomplish the task.

Our biomedical engineering department at the University of California Davis has strong interest in providing students with ample opportunity during their undergraduate careers to learn how to effectively engage in a team. In an effort to enhance student engagement and incorporate principles of teamwork and design earlier into our curriculum, our first year, introductory biomedical engineering (BME) course was redesigned from a traditional, lecture-based survey course to an active, team-based learning course. The Fall 2015 quarter was the first offering of this redesign, and this Works in Progress paper presents the redesign methods used and discusses how students operated in a team as assessed by modes of communication, level of organization, and peer-evaluation.

Methods

The previous structure of this Introduction to BME course consisted of guest lectures covering the five BME tracks offered in our program. The redesign reduced the number of guest lectures from 3.5 to 1 per track, added guest lectures representing various BME careers and two team-based design challenges (DC). This Works in Progress paper focuses on the design and first implementation of the DC component.

There were 142 students enrolled, most of which were first year engineering students (required for BME majors). The class met two times per week, for 50 minutes each, in a fixed-seating lecture hall. Eight out of nineteen total class periods were devoted to the DCs, and on these days, three teaching assistants (TAs) and instructor were present to help facilitate discussion/activities. The first DC was introduced on the second day of class (Wednesday), and devices were tested outside during the next class (Monday). The remaining DC class days were devoted to the second DC, and topics generally followed the steps of the design process.

The objective of the first DC was to engage students in effective teamwork through intentional and reflective practices in the areas of communication, organization and cooperation. The first DC asked students to design and build a device using recycled materials that could transfer 100 milliliters of water from one cup to another though four different mechanisms[5]. The device was required to be initiated by the drop of a marble six inches above the device. The fast paced

nature and rigor of this challenge was intended to put students in the situation where they had no choice but to work together and execute the challenge (i.e. no time to waste).

Students were assigned to teams of four or five based on seating arrangement in the fixed-seating lecture hall. Upon initial team assembly, the thirty teams were asked to assign defined team roles (Facilitator, Organizer, Recorder, Timekeeper, and Materials Manager) and sign a Code of Cooperation, which was adapted by the Boeing Aircraft Group Team Member Training Manual. Students were required to submit a team reflection at completion to reflect on their mode of communication, level of organization, and explanation of the process, if any, that they followed to complete the DC. Lastly, each team member completed a peer evaluation (PE) by distributing 100 points to each of their team members. Comments were mandatory and shared with each student. Students were assessed based on their participation through DC completion and submission of team reflections, as well as their given PE scores. PE scores were used to generate a multiplier (i.e. for a team of 5 students, an average score of 25 would yield a multiplier value of 1), in which their DC1 grade based on participation was multiplied by this value.

In the second DC, teams were given the option to reassign team roles. Students were introduced to the design process, and tasked with designing and making an assistive device to allow a hemiplegic child tie his shoe with one hand using only recycled materials. One of the main objectives for this DC was to provide an opportunity to improve teamwork skills. Students were assessed through three team meetings with their assigned TA (rubric based on team organization, team progress, and team dynamics/contribution was provided), team assignments such as a virtual clinical needs finding exercise, a needs statement and prior art poster, and a materials list. A final reflection asking students to report on how communication and organization evolved since their first DC, a second PE, and participation through completion of the DC on testing day, were also utilized to assess student teams.

A pre-course survey was administered on the first day of class, which included asking students to rate their level of interest in team-based design projects. A final course survey was also administered in which students were asked to rate several metrics regarding the value of working in teams and their level of interest in BME.

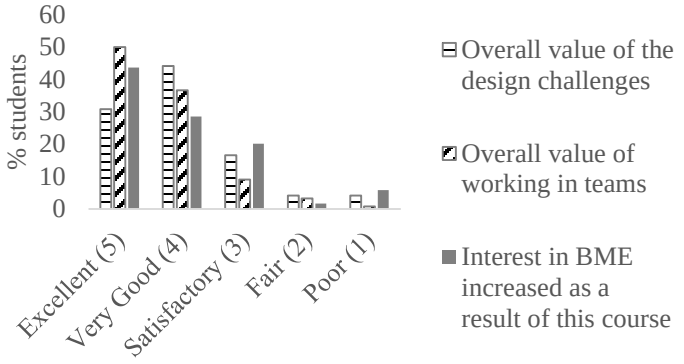
Results

The pre-course survey (94% response rate) indicated that 87% of respondents selected 4 or 5 on a scale of 1-5 (1: no interest, 5: definitely would participate) regarding level of interest in team-based design projects. At completion of the course, a final course survey (Figure 1; 87% response rate) indicated that 75% of respondents selected 4 or 5 (4: very good, 5: excellent) in overall value of DCs, 87% selected 4 or 5 in overall value of working in teams, and 72% selected 4 or 5 in increased interest in BME as a result of this course.

The value that students placed on the team-oriented activities was also evident through team reflections. Common themes were identified to better understand how teams functioned. Most

teams stated that Facebook Messenger and/or group texts were the primary communication modes used. Other reported modes included email and google docs. After the first DC, students emphasized the importance of being open and listening to all ideas in the group. Communication modes stayed mostly consistent, however several groups reported that increased comfort and respect for one another over time also led to communication success.

Figure 1:
Final Course Survey



Most teams described their level of organization as having increased through the course. Comments were related to: team members executing their team roles effectively, the use of delegation to make progress, written notes, and impact of planning ahead. One team stated *"Our organizer did a very good job at scheduling out meetings and making sure we were on track…being on this team has definitely made us better planners and organizers."* Another team commented that *"our organization skills were refined and we were able to accomplish much more in a shorter amount of time."*

Overall PE scores did not show any significant changes from DC1 to DC2. Specifically, 38% of students had higher PE2 than PE1 scores, 42% had decreased PE2 scores, and 20% had the same scores for both evaluations. It should be noted however, that decreased PE scores were also a result of improvement in fellow team member scores. As there was no upper limit to distributed points, some students may have received more than 25 points (for a team of 5) in PE1, and 25 points in PE2 due to improvement in a team member's performance.

Implications and Future Work

The incorporation of DCs in this introductory course led to increased student engagement, team-reflective opportunities to improve communication and organization skills, and reported value of working in teams, which together may have contributed to the reported increased interest in BME. The next course offering will incorporate a discussion section in place of one large lecture class per week to allow for extended team-based discussions/activities and increased interactions between the Instructor/TAs and students. With increased team discussion time, frequent assessments and additional teamwork factors such as conflict occurrence and resolution will also be addressed. The impact that improved teamwork skills may have on students will be evaluated through collection of annual retention data, performance in the capstone design course, and specific questions related to teamwork readiness on our department's annual exit survey to graduating students. The impact will be compared to historical student data, in which the traditional lecture-based introductory course was offered, and used to guide continuous development of our undergraduate curriculum to prepare our students for future success.

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