Flipped Classroom, Team-Based Learning, and Real World Problems in Engineering

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Proposal for the 2013 Newell Innovative Teaching Award

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Overview

In order to actively engage students in their own learning while maximizing the breadth and depth of course content, I have redesigned the two semester thermal-fluid-science sequence in the Engineering Department by utilizing a Flipped-Classroom Model and Team-Based Learning to introduce more realistic application problems to the courses. In response to the revised course format, student participation and student discussion have increased significantly. Students' enthusiasm and curiosity are evident in the classroom, which were not observed in previous offerings of the same course sequence. Students have taken increased ownership of the learning process, come prepared for class, and are able to apply higher-level analysis skills to complex team-application problems.

Description of the Teaching Approach

Since becoming a faculty member, it has been my goal to actively engage students in the classroom in order to enhance student participation and ultimately student learning. At the same time I did not want to sacrifice the breadth and depth of material covered. Working through the text "Creating Significant Learning Experiences" by Dee Fink, during Fall 2010, I was first exposed to team-based learning (TBL). However, while the goals and promises of TBL were very appealing, I questioned the feasibility of implementing TBL in content-heavy, quantitative engineering courses without removal of required course content. TBL is defined by Michael Sweet in "Team-Based Learning in the Social Sciences and Humanities" as "a special form of collaborative learning using a specific sequence of individual work, group work, and immediate feedback to create a motivational framework in which students increasingly hold each other accountable for coming to class prepared and contributing to discussion." The goal of team-based learning is to shift the in-class focus of a course from obtaining knowledge to learning how to apply that knowledge. Considerable focus is placed on harder course concepts, providing students with the opportunity to apply course concepts at higher levels of Bloom's taxonomy (applying, analyzing, evaluating, creating) rather than placing the focus of the majority of class time on lower level knowledge skills (remembering and understanding).

After becoming familiar with screencasts as a way to shift passive lecture content out of the classroom (flipped-classroom model) and attending the Team-Based-Learning Collaborative Workshop during Spring 2012, I decided to redesign the senior level Thermal-Fluid Sciences course (EGR 450) during Fall 2012. Following the initial success of this course, I am currently changing the sophomore-level Thermal-Fluid Sciences course (EGR 250) into TBL format. Prior to using TBL, I taught EGR 450 as a 6-module course with 5 quizzes and one final exam. Each module consisted of roughly 6-8 50-minute class periods of traditional lecture and problem solving, followed by a quiz on the material. For Fall 2012, this course was redesigned using 6 TBL modules, one midterm, and one final exam. Each TBL module consists of:

i) **Basic Knowledge Acquisition Phase**: 3-4 days where students study basic course concepts by reading the textbook and watching screencasts (online lessons) outside of class and then actively participate in course content discussion and basic problem solving during scheduled classtime

ii) **Readiness Assurance Process**: 1 day where students take a multiple choice concept test on the course material, first individually and then in teams, to ensure a baseline understanding of the material covered

iii) **Team Application Phase**: 1-4 days during which teams of 5-7 students each solve complex, real-world application problems related to the course material

Specific innovations in the basic knowledge acquisition phase and the team application phase are highlighted in the following paragraphs.

Basic Knowledge Acquisition: I consider the use of screencasts as the key enabling technology that permits the use of TBL in content-heavy engineering courses without the need to reduce course content. I am using screencasts to record passive "lecture" content and example problems, making them available to students prior to class in the spirit of the "flipped-classroom model." This permits me to more actively engage students during class time, increasing student participation, interest, and ultimately learning. Initially, I uploaded the individual screencasts to MoodleRooms or embedded them in a PDF reading guide for students, as presented during uTech 2013. Since then, my approach has evolved into creating stand-alone MoodleRooms lessons on each course topic, combining 10-15 brief screencasts (on average 2 minutes each) with integrated quiz questions that provide students with instant feedback on their learning. This approach follows the format used for Massively Open Online Courses by Udacity (www.udacity.com) and has been embraced by the students. Figure 1 illustrates one such MoodleRooms lesson, showing an example of a lecture screencast, a lesson progress bar at the bottom, and a menu on the left, where students can advance through the lesson.

Team Application Problems: Each TBL module culminates with several days of solving complex, real-world, team application problems that exceed the problems previously covered in these courses in complexity and difficulty. During Fall of 2012, students analyzed real-world application problems including a) the design of a gasoline engine, b) an efficiency study on a biogas power-plant, c) a drag analysis on shotgun BB shot, and d) a flow analysis for a pipe-cleaning robot at the Pringles Plant. For their final course project, the two student teams competed in the design and construction of aerodynamic bike helmets, culminating in 5 minute promotional video clips of their designs. Screenshots of this truly exceptional student work are shown in Figure 2, and the youtube links to the videos are included here for the interested reader. (Team 1: http://youtu.be/zNwOOvdHW6c, Team 2: http://youtu.be/cPrby-HOIfM)

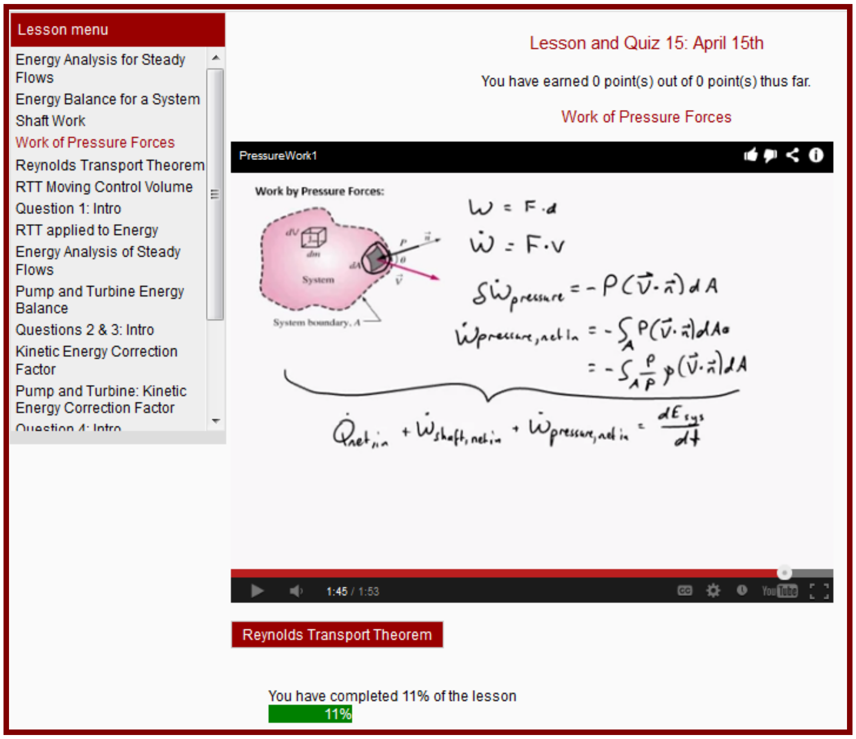

Figure 1: MoodleRooms Lesson

Figure 2: Student Designed Aerodynamic Bike Helmets

Contributions to Engineering Education

Team-based learning has received increased interest within the engineering community in recent years. However, it has mostly been applied to engineering design courses. The present work demonstrates an example of TBL for heavily quantitative engineering courses that retains and even increases content coverage through the use of screencasts, while improving student learning and student/faculty satisfaction. It is believed that this use of TBL and screencasts fits well into the changing academic landscape where an increasing amount of excellent content is made freely available online. Combining a screencast-supported flipped-classroom approach with TBL can be a powerful method to create a learning environment that fosters maximum student learning through the practical application of course content. A full length, peer-reviewed paper on the details of the discussed educational approach for Thermal-Fluids courses has been accepted to the summer 2013 American Society of Engineering Education conference, highlighting the relevancy and contribution of this work to engineering education.

Assessment and Improvement

Overall I see the application of a flipped-classroom approach and TBL as a great success for the Thermal-Fluid Science course sequence at Union. Students seem to gain an improved understanding of course content and are more engaged in the course. Overall, student satisfaction has increased from an average course evaluation score of 3.96/5 during Fall 2010 to an average score of 4.69/5 during Fall 2012. When asked to directly compare TBL to the traditional approach used previously, 8 out of 9 students responded that they prefer TBL and that TBL promoted the best learning. Further, when asked to compare the MoodleRooms online lessons to traditional textbook reading assignments, 9 out of 10 students indicated a preference for the online lessons. To receive discipline specific peer feedback on this approach, I am currently participating in a Virtual Community of Practice for Thermodynamics education, focusing on active learning. While there is certainly room for further improvement through enhanced application problems and improved online lessons, the course redesign has already enhanced student learning and student enjoyment of thermal-fluid sciences at Union.