

Title: The Hybrid Course Experience**Author: Susan M. Stagg-Williams, Chemical & Petroleum Engineering**

Summary: A chemical and petroleum engineering professor redesigns a lower-level course to increase student success, moving lecture elements online and providing more time for in-class problem solving.

Background

Material and Energy Balances (C&PE 211) is a course required of all chemical and petroleum engineering students in the fall semester of their sophomore year. It is a foundational course that serves as a prerequisite for all the upper-level C&PE courses. Therefore, it is fundamentally important for students to truly understand this course's material.

CP&E 211 lecture meets three times a week for 50 minutes and once a week for a two-hour lab section. When I taught C&PE 211 in 2009 and 2010, lectures typically began with my covering basic concepts and general topics. Following this 10-minute overview, I would present a problem and demonstrate on the board how to use the information just covered to solve the problem. We would briefly discuss the answer, and then I would present a more difficult problem for students to solve. Inevitably, we would run out of time to finish the complex problem in class, so I would tell students to finish the problem and we would discuss it at the next class. Typically, though, they would not be able to finish the problem or they neglected to complete it, so we would spend almost half the class going over that harder problem, leaving less time for new material. I felt perpetually behind in the course and, as a consequence, the end of the semester was a flurry of information. My perception was that learning gradually declined as the semester progressed, which was evident in exam grades.

I would also assign homework problems; however, growing enrollment (from an average of 50 students to 90-100) made it impossible to return graded assignments in less than a few weeks. This meant that by the time students got feedback on their work, we had moved beyond the concept; I also had to delay tests until homework was returned.

Under this structure about one-third of the students were not successful; others would complete the class but would have problems in their junior year courses due to not fully understanding the 211 material. I could see students getting frustrated, having trouble, and just giving up. I asked students for feedback on the course, and most of them said that the amount of material in each lecture made keeping up difficult. The material builds, so that if they got behind in understanding—especially early in the semester—catching up became nearly impossible. I believed that a portion of the students who were not succeeding could succeed, but they just did not have the time or the resources to do so, and I did not have the time to devote to each student. Therefore, I began to rethink CP&E 211's structure, ultimately deciding to hybridize the course.

Implementation

I began restructuring CP&E 211 by deciding what material I wanted to keep in class and what material to move online. I knew that I wanted to spend class time on the complicated problems that, in the past, there had been little time for. So I decided to put the lectures online as individual modules.

Using a tablet (Wacom Interactive Pen Display DTU-2231), a microphone (Blue Microphones Yeti Pro USB Microphone) and Camtasia Studio screen capture software, I recorded myself talking about the material, accompanied by my original PowerPoint slides. However, as I would in an in-person class, I talked beyond the slide's information and wrote additional information directly on the slides. Since all engineering students have to do their work on engineering paper, I scanned in a piece of this paper and set it as a Word background. That way, when I would solve a problem as part of the "lecture," I was modeling how the students should approach their own work. I tried to keep the modules short (five to ten minutes), although a few are as long as 20 minutes. Although students do not like the longer modules as well, when asked if I should shorten them at the expense of solving the sample problems step-by-step, the answer was a resounding no. Students who are able to quickly understand the concepts have indicated that they do not watch all of the sample problem solution but use it to check their work. Students who are struggling want to see the step-by-step solution, because they say they like to see the way I think and the process I use to approach the problem. They can pause, rewind, and re-watch each module or part of a module as many times as they need to understand the material; some modules also include embedded quizzes for understanding. This method allows students to customize their learning experience, which I could not do in the traditional lecture class.

Recording the modules did take time, because I was not savvy with editing. In the beginning I would spend a significant amount of time rerecording whole slides when I messed up a few words or a phrase. The entire recording process got much better once I learned how to edit the videos and not be such a perfectionist about the way I sounded on the module. When I asked students if the pauses, um's, and word stumbles bothered them, they all replied that I did that in class so it was natural to hear it on the modules as well.

In order to prepare for each class, students would have to watch the corresponding online module(s); depending on the class there would be several short modules or one longer module. In class I would ask if anyone had questions and either give a short quiz or ask questions about specific points I wanted to make sure they understood. Most in-class time, however, could focus on problem solving. I would present a problem, lay out a timeline, give students time to solve the problem in steps, and then talk through the methods used at each step as a class. For example, I would present a problem and tell them, "In ten minutes you should be able to solve steps A, B, and C;" if things were going well and they were finished with those steps before time was up, they could work ahead. They could do this work in groups or alone. This in-class problem solving was not

an assessment but rather a chance for them to apply their knowledge and practice the necessary skills.

Originally I wanted to also restructure CP&E 211's lab portion to include hands-on components. However, class size made this unfeasible. Therefore I left the lab unchanged; it remained a problem-solving session but, unlike the work done in lecture, the lab work was a graded assessment. Although these problems could still be solved in groups, they were more like exam problems and gave the students an opportunity for additional practice but with higher stakes.

In addition to creating the online modules, I also changed how I approached homework. I moved from traditional, handed-in assignments, to an online homework system. This meant that homework could be mastery-based rather than simply right or wrong; students could try multiple times, without losing points, and would receive immediate feedback. The homework problems used randomly generated numbers so each student had a separate homework problem to complete, which helped minimize copying. Students were able to put as much time into the homework as they needed to get the solution, which again gave them responsibility in the learning process.

Student work

In the Fall 2011 iteration (the first semester of the hybrid redesign), there was a slight decrease in the first exam average score. This, of course, made me very nervous about continuing. However, I had also changed the course slightly to remove a quiz (structured like a mini exam) and included this material in Exam 1. This meant that the 2011 Exam 1 was the first time they experienced a test in my course, while in 2009 and 2010 they had already taken an exam-like quiz prior to Exam 1. Since it was possible that the lower score could be due to this restructuring and the first exam experience, I decided to continue to use the hybrid course structure. When comparing the second exams from 2009 and 2010 to 2011, I saw a small increase followed by an increase of about 10 percent on both the third exam and the final. The larger increase as the semester progressed is attributed to the students' ability to keep up with the material and the course early on and build a strong foundation, allowing them to be more successful as new material was introduced. In 2012, however, the final exam average decreased. Based on student comments, I felt there were two likely causes. First, the exam was late in finals week, when many students were feeling drained. Second, several students told me they felt the problems must be harder than they seemed or that their answers were "obviously" too easy; therefore, some students simply were not confident in their own knowledge and abilities and allowed that insecurity to guide their answers.

An example of exam 1 can be seen [here](#), examples of exam 2 can be seen [here](#), [here](#), and [here](#), and an example of exam 3 can be seen [here](#).

Since changing the homework to be more mastery-based, those scores have increased. While this would clearly have a small effect on overall grades for the course, it is also having an effect on how much time students spend on homework, especially those students who are struggling more on the problems. If students want to spend more time solving a problem, they are free to do that; they decide how much effort to put in. Working a problem multiple times helps reinforce concepts, which is ultimately the goal of the homework.

The final grade distribution for 2009-2012 can be seen [here](#) and the course enrollment numbers are [here](#).

Reflections

Students' responses to the hybrid course and appreciation for the format were better than I had expected. For one thing, the new structure lets students figure out what they need to be successful, whether it be reviewing modules before a test or working through the homework several times to truly grasp a concept. The new structure also helps students better understand the amount of effort needed to succeed in both the curriculum and the field.

Relatedly, and somewhat unexpectedly, I saw students taking responsibility for their own learning. For example, when we first moved on to new material following an exam, as students worked on an in-class problem one student admitted to being lost because he had not watched the module and that it was his fault he was behind. I had not had students admit to not having read the book before class in pre-hybrid iterations.

I found that the redesign helped the overall classroom environment. All courses have material that has to be covered but is not very exciting. Now the material is in modules, so although it may still be dry, students can engage with it on their own terms. In previous semesters, I had days where I walked out of class feeling like the lecture had been a disaster. Students were lost, not engaged, and frustrated at not being able to follow the material, and I was frustrated with the experience. With the hybrid course I found that I did not have those days. The class was more exciting and energized because it was not scripted. Attendance was also high, because material discussed in class was not found outside of class and, thus, students valued class time more.

Overall, I would not hesitate to make the shift again or to apply some hybrid elements to other courses. In fact, I have already applied some elements in one of my senior-level classes. There, although I did not do audio, I did scan in my notes to create a kind of resource library for the students' lab work; class time could then be spent on other skills with which the students typically struggled, such as writing strong lab reports. I also think that these changes need not necessarily be confined to my course, but could be implemented to different degrees throughout the School of Engineering.