Work in Progress: Transforming a Course

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Third year students at Lafayette College enroll in an Applied Fluid Dynamics and Heat Transfer course the semester following a theoretical Transport Phenomena course. The student learning outcomes for Applied Fluid Dynamics and Heat Transfer are shown in Figure 1. They are significantly different from those in a typical transport phenomena course, which include the ability to identify, simplify and solve differential equations used to describe transport phenomena and recognize and use the similarities between the theoretical models for momentum, heat and mass transport. Student learning in both courses is assessed via weekly homework assignments, one or two midterm exams and a final exam. In the applied course, however, the "artificial" exam questions were not always a good indication of student learning. Writing exam questions that could clearly show student understanding of the applications and fairly grading the student answers was challenging. In addition, over the past few years, the effect of test anxiety has become noticeable – good students who have shown an understanding of the material while discussing homework problems during office hours perform miserably on the exam. Was there another way to fairly assess learning without causing student anxiety? Thus, in Spring 2017 the course was modified to address three research questions:

- Can students learn the course material through inexpensive hands-on projects conducted during class time?
- What project should be developed for each segment of the course?
- Can the instructor assess individual student learning through group project reports? If so, how should the report rubric be structured to clearly communicate expectations?

Previous research has clearly shown that students do learn course material through hands-on projects [1, 2]. Thus, this paper will address the initial results from the second and third questions.

Learning Outcomes:

In this course we will explore the application of fluid dynamics and heat transfer from the chemical engineer's point of view. Students will be introduced to the design of equipment used in chemical processes. After completing this course, students will be able to formulate and solve chemical engineering problems

1. Involving pumps and mixing processes,
2. Involving heat transfer and sizing heat exchangers,
3. In evaporation and drying processes,

and be able to

4. Apply computer methods used to solve chemical engineering problems.

Figure 1. Learning outcomes for Applied Fluid Dynamics and Heat Transfer.

The student learning objectives for each segment of the course were used to develop the five projects. Each course segment was about three weeks long, and contained lectures, problem-solving sessions and time to gather data for the project. No exams were given during the semester, however, each segment ended with a quiz with questions at the lower levels of Bloom's Taxonomy. The projects were completed in small groups (two to six students). The grading rubrics lined up with the learning objectives and were at the higher levels of Bloom's Taxonomy. The semester ended with a final exam, with questions at the higher levels of Bloom's Taxonomy.

Project Descriptions

The students are simultaneously enrolled in a laboratory course, where the experiments require multiple operators and two or three hours to collect data under different initial conditions. These projects were not meant to replace the lab. They were developed to allow students additional opportunities to see how things work, and to encourage them to observe engineering principles in everyday activities. The learning objectives for the projects were also different from the laboratory experiment objectives. Details of the projects and their learning objectives will be described when the project is complete. Data for all projects (described below) was gathered during a two-hour class session.

- Mechanical energy balance: Students pump non-Newtonian xanthan gum solutions and measure capacity at different heads [3]
- Mixing: Students measured the power drawn and the mixing time for six different impeller types
- Heat Exchange: Students estimated the area and heat transfer coefficient for a small air-water heat exchanger
- Evaporation: Students created a dynamic spreadsheet that could analyze different evaporation systems (single effect, multi effect, boiling point elevation) using a steam table Excel Add-In [4]
- Drying: Students collected and analyzed data as they dried a food of their choice in a table top dehydrator

These five projects covered the student learning objectives for the course. Equipment and supplies were minimal, with most equipment already available in the lab or purchased inexpensively online. The project equipment was portable and set up safely in the classroom. However, some projects did require significant instructor preparation time.

Assessment of Student Learning

The distribution of final grades in this course was similar to the previous three years. The reports showed that the students were able to apply the course concepts to the projects. The analysis was often challenging. For example, the heat exchanger they analyzed was neither a shell-and-tube nor a flat plate heat exchanger. The students had to make many assumptions in order to estimate the overall heat transfer coefficient. The reports showed that the students were able to make logical assumptions, and operate at the higher levels of Bloom's Taxonomy to analyze the data. It was not always smooth - some students complained about the lack of precise data or accurate models for the projects. Grading the project reports required as much time – or more – as grading exams.

As the course was structured, it was not possible to assess individual student learning through the project reports. While the students were working on the analysis, many groups came to office hours to discuss assumptions and questions the students had about the application of theory. During this time, through questioning individuals, it was possible to note who was not participating fully. However, it was not apparent in the final reports. To ensure participation by all members, peer evaluation, “private” oral reports, individual project reports or individual worksheets are being considered.

Analysis of the final exam showed that the majority of the students recalled the concepts and were able to apply them to the exam problems. Overall performance was similar to previous years with an average of 84% and a range of 53 – 95%. (No IRB was requested for this initial project, so detailed results may not be published. An IRB request has been filed for future work.) However, students at the lower end of the spectrum, performed worse on the exam than they had on the projects. Most likely they did not participate fully in the project report and had not fully understood the concepts. Ways to address this are being considered and will be discussed at the presentation.

<u>Student Evaluations</u>

One question on the student course evaluations is “How did the various components of the course contribute to your learning?” Almost all students (38/41) indicated that the projects were the major component, followed by homework and lectures. Only one student considered the projects “a waste of time”. Other students wrote that the projects “were more challenging than homework and ensured thorough understanding”, “made you think analytically” and were “straight forward and rewarding in that they were relevant”.

<u>Future Work</u>

The straight-forward, one-question tests given after each project were designed to lower the significant “test anxiety” exhibited by the students. According to the American Test Anxiety Association 20% of students may suffer. Increasing numbers of students are affected and it has a negative impact on academic performance [5,6]. However, the short tests, designed to take about 10-15 minutes, and require just a basic understanding of the concepts, were not taken seriously by the students. Average scores ranged from 85 – 95%. Several options are being considered for the next offering of the course based on research by math and physics educators who have proposed different exam methods.

Assessing the project reports was challenging and took as much or more time than grading exams. Ways to streamline the process, such as individual worksheets, are being considered, but much of the student learning occurred because the students were not led to a single solution method. Opportunities for student creativity must be maintained.

<u>Conclusions</u>

The students enjoyed the projects and most students learned the core principles of the course through them. The projects reports were thorough and showed a depth of understanding that is difficult to assess through exam questions.

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