Building Bridges: A Course to Transition Chemistry Students to Chemical Engineering

Z. Otero Keil and R. P. Hesketh, Chemical Engineering Program, Rowan University, Glassboro, NJ, 08028

There is a growing population of chemistry students and graduates interested in pursuing a graduate degree in chemical engineering. In general, these students are required to take the undergraduate core and mathematics courses before they can participate in a graduate engineering program. Although some undergraduate course work is still necessary, transition courses that provide students with experimental experiences and theoretical background can serve to enhance learning and shorten the time required to complete a Master of Science degree in engineering.

Since 1995, Rowan University has offered engineering graduate courses at the University and at industrial sites. The University welcomed its first undergraduate class in 1996 and expects to graduate approximately 100 students in May 2000. Rowan Engineering Programs include several unique and innovative approaches to graduate and undergraduate education. Transition courses especially designed to give chemistry students and graduates a strong background in chemical engineering principles is one example of the exciting innovations at Rowan University.

The course highlighted in this work was developed with the Department of Chemistry and Physics. It included topics in fluid mechanics, and heat and mass transfer. Some reaction kinetics was also presented. Laboratory experiences to illustrate basic principles were an important part of the course. Although the first class was small (9 students), student response was positive and two students are pursuing graduate degrees in engineering. One student is presently enrolled in a doctoral engineering program. For students with a chemistry background, this type of experience provides a strong beginning in a chemical engineering graduate program.

Background:

The Department of Chemistry and Physics had several students interested in a special topics course that would expose them to chemical engineering principles. They requested that the College of Engineering consider developing such a course. The College of Engineering considered this an opportunity to work with a department outside of the College and to provide a service course to the University. In addition, this course could serve to attract employed chemists with an interest in graduate studies or life-long learning. As a result, the Chemical Engineering Program designed the course in collaboration with the Department of Chemistry and Physics. Chemical engineering faculty taught the course in the fall 1998 semester. Nine students registered and eight completed the course. Three of the students were employed chemists, two were science high-school teachers enrolled in the College of Education Graduate Program and four were seniors majoring in chemistry.

The Course - ***Advanced Topics: Chemical Engineering Principles for Chemists***

The course was divided into four modules: Engineering Mathematics, Balances, and Units, Fluid Mechanics, Thermodynamics and Kinetics, Heat and Mass Transfer. The course combined lectures/discussion with illustrative laboratory experiences. The aim of the classroom and laboratory activities was to connect the familiar chemistry principles with engineering processes and principles. The course was fast-paced and the laboratory experiences demonstrative and not comprehensive. The breadth of the course made the use of multiple sources including journals an important course component.

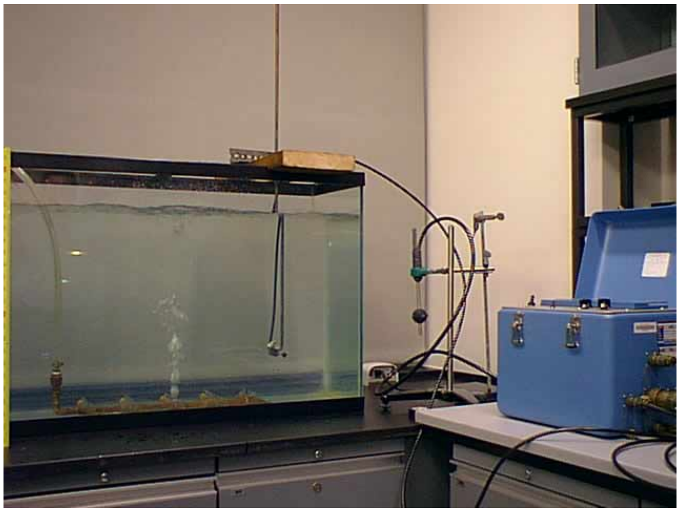
The course grading was relatively standard in that there was homework and two examinations. One examination was given in class and the second was a take-home examination. Each student selected an engineering application of interest in the middle of the semester. A written and oral report on the application was the final examination for the course. The written report and oral presentation needed to include a detailed description of the application, possible improvements, the future of the application, the chemical engineering principles involved, and environmental and safety concerns relating to the application.

The Course Modules:

I. Engineering Mathematics, Balances and Units: This module included a review of basic calculus with chemical engineering applications. It also included basic statistics and an overview of mass and energy balances. Units and unit conversions were discussed. This module had a large class problem-solving component. A principle was introduced and immediately followed by an example. A problem was proposed and partially set up on the board. Students then worked in their groups to complete the solution to the problem.

II. Fluid Mechanics: Fluid properties including non-Newtonian behavior were discussed. Students used a Brookfield@ viscometer to measure the rheological properties of ketchup. Students were asked to identify the type of fluid (Bingham plastic). Pipe flow and pumps were included in this module. Students experimented with an Armfield@ centrifugal pump. The software associated with the pump unit allowed students to quickly see the effect of flow rate on efficiency. Concepts in multi-phase flow were introduced with a focus on gas/liquid systems. Students studied gas/liquid flow patterns and the equations governing flow behavior in a gas sparged tank-type device. Students made velocity measurements using a Marsh-McBirney@ electromagnetic flowmeter. The concepts of two-dimensional flow and turbulence were discussed. Students measured the effect of liquid height and gas flow rate on the average velocities and velocity oscillations. The figure below shows the gas sparged tank and the electromagnetic flowmeter with probe.

Gas Sparged Laboratory Tank with Probe and Flowmeter



III. Thermodynamics and Kinetics: In general, chemistry students are familiar with thermodynamics and kinetics principles. This module included equations of state. The differences between equations of state in predicting thermodynamic and volumetric properties were discussed. The idea of power cycles and their role in chemical engineering applications were introduced. Types of reactors and the importance of integrating kinetics and reactor design for engineering applications were discussed. Students were introduced to Hysys@, an advanced process simulator software package. This allowed students to perform calculations and obtain a graphic representation of their calculations with a process spread sheet. Students could easily change parameters and investigate their effect on the thermodynamics or kinetics of a process. Students were exposed to an overview of the chemical engineering principles of distillation and reactor design.

IV. Heat and Mass Transfer: Basic transport principles were discussed and a connection was made between heat and mass transfer and fluid mechanics. Students were exposed to the concepts of heat and mass transfer coefficients. The coffee brewing process was used to illustrate these principles. Students measured the heat loss from coffee in various cups (Styrofoam@ and two different types of commercially available insulated travel mugs). Students brewed the coffee and measured the coffee temperature in each of the cups using a thermocouple over a three hour period. The experiment was instrumented so the temperature measurements were taken automatically and stored in Excel@. Students were able to calculate a heat transfer coefficient for each of the cups. They used the heat transfer coefficient to rank the cups as to how well the fluid (coffee) temperature was maintained.

Students experimented with the effect of interfacial area on mass transfer by measuring the quality of the coffee brewed as a function of coffee particle size. Students ground coffee beans using three grinding times. They brewed coffee using the three different grounds and coffee beans. They used a spectrophotometer to measure the absorbance of the coffee. Using a previously prepared calibration curve, students were able to obtain the coffee concentration in their sample. They were able to relate the coffee concentration to grinding time. Students were able to understand the connection between mass and heat transfer and the area available for transport.

Conclusions and Recommendations:

The course was well received as evidenced by very positive student evaluations. It was a fast-paced overview course. As a result, it was not possible to develop the detail in analysis or calculations that is typical of a chemical engineering course. However, students understood the principles and were able to carry out the calculations. They clearly understood the applications associated with the theory presented as evidenced by examinations and their final reports. Additional presentation of chemistry principles would have been helpful and would improve the course. This is an excellent course to team-teach with a chemistry faculty member.

The course met the objectives of introducing chemistry students to chemical engineering principles. Two of the students are presently pursuing graduate degrees in engineering and one student is enrolled in an engineering doctoral program. The theoretical presentations combined with examples and class problem-solving and illustrative laboratory experiences made this a positive and enjoyable course for students and the instructor. The course is a good vehicle for attracting new students to chemical engineering graduate programs, providing a service course to the University, and providing a team-teaching opportunity between chemistry and chemical engineering departments.