



University
of Colorado
Boulder

i>CLICKER CASE STUDY: DEPARTMENT OF CHEMICAL AND BIOLOGICAL ENGINEERING, UNIVERSITY OF COLORADO

Department of Chemical and Biological Engineering improves the quality of student participation for one of the most conceptually challenging courses

Thermodynamics course applies i>clickers during course lectures to improve student comprehension of course material.

Challenge:

Students struggle with understanding and applying specific course ideas to real world problems.

Solution:

Application of the i>clickers successfully improves student engagement, resulting with an increase in more sophisticated student questions during course discussions.

Benefits:

Using i>clickers, gives the class the opportunity to concentrate on key concepts with it's interactive learning model.

Motivation For Using i>clickers

- To improve student understanding of conceptually challenging topics
- To increase student participation and learning
- To understand which course topics are difficult to grasp for students

Technology Implementation & Usage

Obtaining/Registering i>clickers: i>clickers are sold at the college bookstore. i>clickers are required because students are graded on their responses.

Taking Responsibility: Students are required to register their i>clickers through the roll call (in-class registration) software feature.

Classroom Application: As part of the course, a course management system (Blackboard) is used, and screencasts (www.learncheme.com) that are prepared for students to watch on their own. The class is presented using a tablet PC and OneNote software. PowerPoint slides are printed to the OneNote software; then the tablet pen is used to write on the tablet in class, and the tablet screen is projected to a large screen at the front of the room.

i>clicker Grading Policy: For clicker questions, students receive 3 points for every correct answer and 2 points for every incorrect answer. They are only graded on the final answer after peer discussion. The five days with the lowest grades are not counted in the semester grade, and the clicker grades are 10 percent of the course grade. Clickers are used every class period, with between three and six conceptual questions asked per class. Only conceptual questions are used.

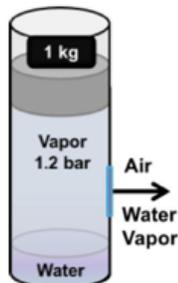
“ It is a more enjoyable way to teach, and the students are much more engaged (essentially, no one is reading the newspaper and students are not looking at their laptops).

John L. Falconer, Department of Chemical and Biological Engineering
University of Colorado, Boulder

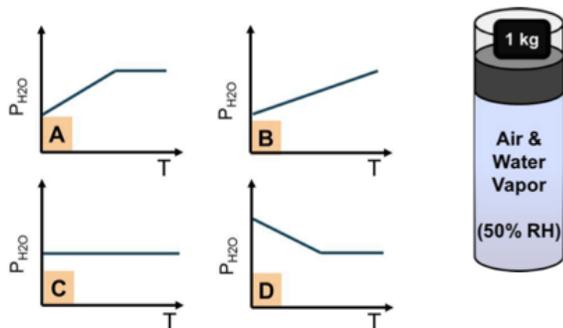
Daily Use/Questions Asked: More than 500 ConcepTests for chemical engineering thermodynamics are available online at www.learncheme.com; two examples are presented here:

Liquid water is in VLE at 1.2 bar with water vapor and air in a piston-cylinder. All the air is removed through a selective membrane, and half the water vapor is also removed. Pressure and temperature are constant. What happens?

- A. All of the water vaporizes.
- B. All of the water condenses.
- C. Some of the water vaporizes.
- D. Some of the water condenses.



This piston-cylinder contains air and water vapor (50% relative humidity). Which is the correct plot of partial pressure of water versus temperature, as the temperature decreases?



Course Overview

Course Title/Subject: The Chemical Engineering Thermodynamics course introduces classical thermodynamics, with emphasis on topics of interest to chemical engineers, including non-ideal gases, single-component phase equilibrium, multi-component phase equilibrium, chemical equilibrium, and fugacity as a driving force for mass transfer, in addition to the first and second laws, state functions, and cycles.

Typical Enrollment/Student Information:

The class has over 100 students, of which 95 percent are chemical engineering or chemical and biological engineering majors. The remaining students are environmental engineering majors.

Course Structure: This 3-credit course meets three times a week for 50 minutes each session in a lecture room. It usually has an advanced TA and one other graduate TA. The TAs grade homework assignments, develop solutions for homework, respond to questions sent to the course e-mail, post materials on the Blackboard course management system, process and record i>clicker grades, and help grade exams. The advanced TA presents two or three classes.

Course/Student Challenges:

In end-of-the-semester course evaluations completed by the students, thermodynamics is rated the most conceptually challenging course in the department. The course is challenging both because of the number of abstract concepts introduced and the vast amount of material to be covered. Students struggle with understanding and applying the ideas of entropy, fugacity, and phase equilibrium.

Course Grading Policy:

A fixed grading scale is used for the course with the minimum numerical scores for A, B, C, D, and F included in the syllabus at the start of the semester.

- Homework assignments 15%
- Exams (two) 35%
- ConcepTests in class (i>clicker grades) 10%
- Reading quizzes 10%
- Final exam 30%
- In-class participation (extra credit) 2%

Results

- ▶ **Active Learning** i>clickers provide students with a new outlet to engage and participate, while advancing their knowledge and comprehension of the course topics covered.
- ▶ **Increased Interactivity** Students actively participate in answering questions throughout course lectures, and consider the i>clicker sections the best part of the course.
- ▶ **Thoughtful Discussions** Students raise their questions in both quantity and quality throughout the course duration.
- ▶ **Improved Attendance** There is an increase in student attendance throughout the course semesters, with positive student feedback.

Conclusion

i>clickers, ConcepTests, and peer instruction have been used in the course since 2002 and has worked extremely well. There has been a dramatic improvement over lecturing. It allows class time to be used for the important aspects of the course. Using clickers and ConcepTests in class also means that conceptual questions are included on homework assignments and on exams, and the exams are more challenging than before this teaching approach was used.

One of the keys to making i>clicker work well in class is to not use questions that are too easy. That is, with ConcepTests, 30% of correct answers are encouraged on the initial individual responses. If 80% of the class can answer the question correctly, then it is not a good use of valuable class time.

The beginning of the semester is used to explain why this type of teaching approach is applied and what the benefits are. Students are much more engaged (essentially, no one is reading the newspaper and students are not looking at their laptops), and studies show that using this approach results in increased learning.

Two papers have been published that describe using ConcepTests and i>clickers in class for chemical engineering thermodynamics:

Falconer, J. L., "Use of ConcepTests and Instant Feedback in Thermodynamics," *Chemical Engineering Education* 38, 64–67 (2004).

Falconer, J. L., "ConcepTests for a Chemical Engineering Thermodynamics Course," *Chemical Engineering Education* 41, 107–114 (2007).

As a result of using i>clickers in class, screencasts have been developed with solutions to example problems, software tutorials, exam reviews, and explanations of concepts. This is described in the following publication:

Falconer, J. L., deGrazia, J., Medlin, J. W., & Holmberg, M., "Using Screencasts in Chemical Engineering Courses," *Chemical Engineering Education* 43, 302–305 (2009).

In addition, more than 120 thermodynamics screencasts are posted online at www.learncheme.com.

“ It was an eye-opening experience when I first started using clickers, and I saw how many students did not understand basic concepts, including ones that they should have learned in previous

John L. Falconer, Department of Chemical and Biological Engineering University of Colorado, Boulder