



Teaching/Learning Resources for Chemical Engineering: www.LearnChemE.com

Dr. John L. Falconer, University of Colorado Boulder

Professor of Chemical and Biological Engineering

Dr. Janet L. de Grazia, University of Colorado, Boulder

Dr. Garret Nicodemus, University of Colorado Boulder

Dr. Nicodemus has taught a variety of different classes in chemical engineering at the University of Colorado Boulder. He has helped build the www.learncheme.com inventory of screencasts, conceptests and simulations in chemical engineering courses. His interests have been in developing active learning methods and incorporating technology in the classroom.

Mrs. Katherine Page McDanel, Dept of Chemical & Biological Engineering, University of Colorado Boulder
Michelle Medlin, University of Colorado

Teaching/Learning Resources for Chemical Engineering

Abstract

Additional teaching/learning resources were prepared for chemical engineering students and faculty and made available directly on www.LearnChemE.com or linked to from the website. These resources include ConcepTests, screencasts, interactive *Mathematica* simulations, an interactive tutorial module, and a thermodynamics course package that uses active learning methods. In addition to preparing new screencasts, some screencasts were replaced based on feedback, interactive screencasts were prepared, links were created between related screencasts, more channels were added to YouTube, and screencasts were prepared that demonstrate how to use the interactive simulations. The screencasts were played/downloaded more than 2.4 million times in the last twelve months.

Overview

The LearnChemE website has been updated to make it more accessible and significant new resources have been added. The objective of the website is to provide teaching/learning materials for chemical engineering students and faculty, but many of the materials are useful for other engineering majors. The changes include:

- Addition of several hundred ConcepTests so that more than 1,600 ConcepTests are available to faculty.
- Preparation of more than 350 screencasts so that links are now provided to more than 1,250 screencasts, which are located on YouTube. Screencasts are now available for eleven courses. Closed captioning was added for more than 400 of these screencasts.

- Preparation of more than 70 interactive *Mathematica* simulations, which are located on the Wolfram Demonstration Project website and are accessible from www.LearnChemE.com
- Preparation of more than 100 interactive screencasts, which allow students to select answers to conceptual questions and receive corresponding feedback.
- Improving the organization of both the website and the screencasts on YouTube.

Screencasts

Screencasts are short screen captures, usually of a tablet PC screen, with narration by an instructor; their average length is less than seven minutes. They can be used by faculty to replace or supplement material presented in class, or they can be used by students for self-study.^{1,2}

Screencasts are inherently interactive because students use them at their own pace; they can pause, rewind, or skip sections.

To further increase their interactivity, we prepared screencasts that allow students to answer questions during the screencast to test their understanding and receive

tailored explanations when they select an answer. As shown in Figure 1, when a student selects an answer they are sent to another screencast that tells if their answer is correct/incorrect. If correct, that screencast explains why, and if incorrect, they are given hints in many cases and then given the option to select another answer.

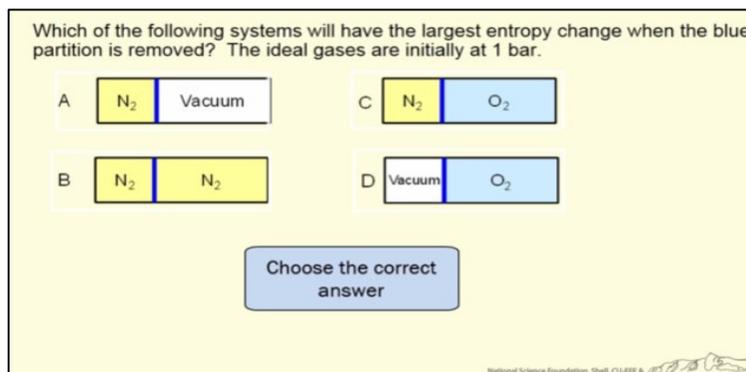


Figure 1: Screenshot of an interactive screencast with an embedded link to each answer.

We also improved how the screencasts are organized. For courses with over 100 screencasts, we created separate, course-specific YouTube channels where screencasts are organized into playlists by topic. Playlists are shorter, making it easier for users to navigate. We also added more textbook table of contents and linked screencasts to chapters in the textbooks, and simplified the existing links from textbooks.

Because the FE exam form was revised since we created the links to screencasts useful for FE exam review, we have updated our website to reflect these changes. An FE exam playlist was created on YouTube as well as a specific YouTube channel.

Active learning materials

An active-learning course package for chemical engineering thermodynamic was added to the instructor resource section of our website. The course package contains complete resources so that an instructor can use them in class and for assigned activities outside of class. It includes daily class notes with instructor notes, homework, exams, suggested syllabus, and active learning resources. The course package provides instructors with all the resources necessary to implement a flipped classroom, thus lowering the barrier for instructors to implement evidenced-based, active learning into their course. Another course package, for chemical engineering material and energy balances will be added in early 2015.

Interactive *Mathematica* simulations

Interactive *Mathematica* simulations allow the values of parameters to be changed by the user by moving a slider on the computer screen, and *Mathematica* solves the equations almost instantaneously and displays the new results, usually in graphical form. These simulations can be

used in class or as part of assignments where students must provide physical explanations for observed behavior. Figure 2 shows a snapshot of an interactive simulation for kinetics/reactor design in which concentrations are calculated in a batch reactor as a function of time. This simulation is for a reaction network of three reactions, and the rate constants of each reaction can be

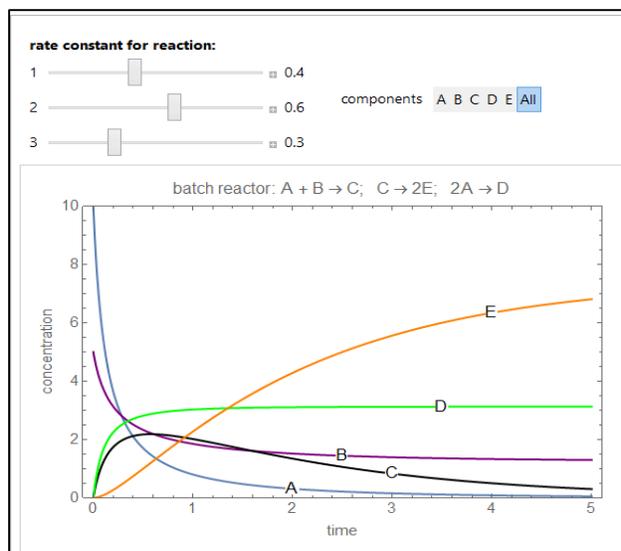


Figure 2: Snapshot of an interactive *Mathematica* simulation for a batch chemical reactor.

changed to observe the effect on the product distribution. It is available at

<http://demonstrations.wolfram.com/BatchReactorWithMultipleReactions/>. We have published more than 70 interactive simulations on the Wolfram Demonstration Project website, mostly for thermodynamics, kinetics/reactor design, and fluid mechanics.

We used some of these simulations in our chemical engineering thermodynamics course in fall 2014, and about 80% of the students were very positive (“the interactive simulations were the best thing that could even imagine”, “the interactive simulations are incredibly useful”, “Really liked the simulations. You should use more of these”). Some of the remaining 20% found them useful in some cases, but said they would be more useful if better explained.³ Thus, we started creating 3-5 minute screencasts that describe how to use each simulation.

Interactive *Mathematica* tutorials

An interactive tutorial for student self-study was created to help students better understand binary vapor-liquid equilibrium for ideal solutions. This topic can be confusing to many students, particularly the graphical representation of system behavior, such as in P-x-y and

T-x-y diagrams. This tutorial combines multiple interactive *Mathematica* simulations with screencasts and text explanations for the difficult concepts. The screencasts and simulations give students opportunities to practice with feedback so that they will obtain increased understanding.

Lever Rule

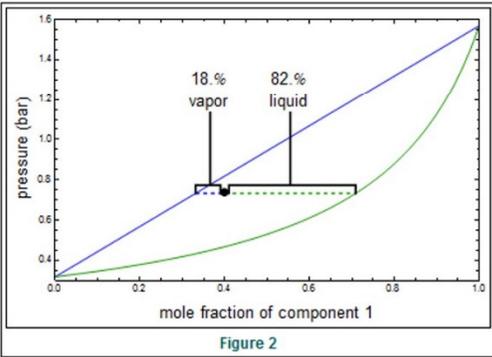
The lever rule is used to determine the relative amounts of liquid and vapor in the system.

An explanation of the lever rule is shown in this [Screencast \(Lever Rule\)](#) ← Embedded screencast link

liquid amount present at z : $f^L = \frac{y_1 - z_1}{y_1 - x_1}$

vapor amount present at z : $f^V = \frac{x_1 - z_1}{x_1 - y_1}$

Mouseover **Figure 2** to see what points are used in the lever rule calculation.



← Interactive simulation

Figure 2

1. Test Yourself ← Question

Based on the ideal mixture in the P-x-y diagram (**Figure 2**), use the lever rule to calculate the amount of liquid and vapor present for an overall molar composition $z_1 = 0.6$. Note that the composition of component 1 in the liquid phase at constant pressure is $x_1 = 0.33$ and in the vapor phase, $y_1 = 0.71$.

Figure 3: Screenshot of interactive tutorial in *Mathematica*. This shows an interactive simulation, a student quiz, and a link to a screencast. Available at www.LearnChemE.com/simulations/#interactive_tutorial.

The screencasts are simplified versions of the type published on the Wolfram Demonstration Project site; only one variable can be changed in each simulation so new ideas are introduced one at a time. A series of simulations then lead students through a particular topic. We prepared a preliminary version of this VLE tutorial (www.learncheme.com/simulations/#interactivetutorial) and an annotated screenshot is shown in Figure 3. The tutorial, and others that we plan to prepare, will be put into a webpage in a format so additional software is not required, and students can answer questions within the tutorial.

Conclusion

We made numerous improvements to our teaching/learning resources for chemical engineering students and faculty and made them available directly on www.LearnChemE.com or

provided links on our website. These resources include ConcepTests, screencasts, interactive *Mathematica* simulations, an interactive tutorial module, and a thermodynamics course package.

In addition to producing new screencasts, we replaced screencasts with errors, prepared interactive screencasts, linked related screencasts, added more channels to YouTube, and prepared screencasts demonstrating how to use the interactive simulations.

References

1. Falconer, J., deGrazia, J., Medlin, J.W., & Holmberg, M. Using screencasts in chemical engineering courses. *Chem. Eng. Educ.* 43, 302–305 (2009).
2. Falconer, J., Nicodemus, G., deGrazia, J., & Medlin, J.W. Chemical engineering screencasts. *Chem. Eng. Educ.* 46, 58–62 (2012).
3. Falconer, J. & Nicodemus, G. Interactive *Mathematica* simulations in chemical engineering courses. *Chem. Eng. Educ.* 48, 165–174 (2014).