Using online resources, including interactive simulations, to teach chemical engineering. Q. When is a simulation better than a lab experiment? A. Come to this session and find out! Teaching/learning resources for many core chemical engineering courses have been developed over the last ten years at the University of Colorado, and they are available on www.LearnChemE.com. This session provides an overview of these resources (screencasts, ConcepTests, interactive simulations, step-by-step quiz simulations, interactive self-study modules, active-learning course packages, and student resources on how to study and learn), and tips on how to use them in your course. The resources can be used modularly; either instructors or students can decide which resources are useful for their course. Studies show that interactive simulations improve student learning and actively engage students. They are similar in some ways to lab experiments, but they allow students to more readily change values of parameters and observe how the system responds.

Using online resources, including interactive simulations, to teach chemical engineering

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Resources on www.LearnChemE.com
Screencasts on https://www.youtube.com/user/LearnChemE
CACHE Teaching Resource Center (course syllabi, links, software) https://cache.org/teaching-resources-center
Active learning
  ○ increases student performance
  ○ decreases student failure rates.

Faculty may hesitate to adopt because
  ○ perceived time commitment
  ○ concerns about how students will respond

Resources to lower the barriers to transforming courses
  ○ ConcepTests
  ○ Screencasts
  ○ Interactive simulations
  ○ Quiz simulations
  ○ Interactive self-study modules
  ○ Course packages: complete course notes, exams, assignments, etc.
Force balance on rotating gate
Screencasts

Screencasts are short screen captures, usually of a tablet PC, with instructor narration. They supplement textbooks and lectures by featuring solutions to example problems, explanations of concepts, software tutorials, descriptions of diagrams, and material reviews. They are made and reviewed by faculty. (CC) indicates the entire topic has corrected closed captioning. Interactive screencasts present a multiple choice question where the viewer chooses an answer within the video. The video response guides the user to the correct answer and explanation. There are over 1,500 screencasts available for the following engineering courses/topics:

- Catalysis: 28 videos (CC)
- Chemistry: 106 videos (CC)
- Engineering Computing: 91 videos (CC)
- Engineering Mathematics: 31 videos (CC)
- Fluid Mechanics: 201 videos (CC)
- Fluid Mechanics (Interactive): 53 videos (CC)
- Heat Transfer: 98 videos (CC)
- Kinetics/Reactor Design: 323 videos (CC)
- Mass/Energy Balances: 171 videos (CC)
- Materials Science: 49 videos (CC)
- Process Control: 79 videos (CC)
- Process Design: 69 videos (CC)
- Separations/Mass Transfer: 85 videos (CC)
- Statistics: 32 videos (CC)
- Thermodynamics: 336 videos (CC)
- Thermodynamics (Interactive): 43 videos (CC)
- FE Exam Review: 179 videos (CC)

> 2,000 ConcepTests
https://sites.google.com/a/learncheme.com/learncheme/conceptests/concepttest-inventory
Consider two well-insulated tanks of equal volume. The left tank contains an ideal gas at 10 bar and 350 K, and the right tank is evacuated. The valve is opened to pressurize the tank on the right (until the pressures in the two tanks are the same) and then immediately closed. The heat capacity is constant. The average temperature in the tanks when the valve is closed is:

A. <350 K
B. = 350 K
C. > 350 K
D. need more information

ConcepTest Inventory

Over 1,800 ConcepTests are available for seven chemical engineering courses:
> 190 Interactive simulations [http://www.learncheme.com/simulations]

- Used extensively in physics [1,3,4],

- Student interactions with simulations have positive effects on learning.[5–7]

- Promote self-directed inquiry and exploration.[8]

Some browser based

Psychrometric chart
Simulation options

Reversible/irreversible expansion/compression
Visualize processes: **Batch distillation**
Browser-based simulations

**T-x-y diagram quiz simulation**

**Construct a Temperature-Composition Diagram for VLE**

Step 4/7

Click and drag the black points to draw the dew-point curve.

Pressure = 0.6 bar

The saturation pressures for each component are plotted versus temperature.
Interactive simulations

- allow the user to manipulate variables and receive instant feedback
- allow students to construct their own understanding.[1]
- students approach simulations differently from the way they approach in-class experiments.
- students doing an exercise with an interactive simulation
mastered the concepts better on the final exam than students who did a laboratory exercise on the same topic.

○ For one topic, 80% of students who used a simulation demonstrated mastery of the concepts, but only 20% of students who did not use the simulation showed the same kind of mastery.

Interactive simulations

○ Demonstrate concept or explain diagram
○ Easy to use - not too many options
○ Actively engage students
○ Observe behavior that hard to observe in real time
○ Students like them
○ Use with ConcepTests in class (part of course packages)
○ Use with assignments

Positive feedback from students

“These interactive simulations were amazing!”
“Really liked the simulations. You should use more of these”
“The interactive simulations are extremely useful.”
“The interactive simulations were the best thing that could even imagine.”
“The simulations were very helpful to me. I'm a visual learner, so lectures don't always stick but diagrams always have been very helpful.
“The interactive simulations are incredibly useful in understanding the
material, especially vapor-liquid equilibrium and vapor liquid-liquid equilibrium.”

“I enjoyed using the interactive simulations. Thought they provided an excellent visual learning tool that added tremendous value to the class.”

“The interactive simulations were very useful because I could test every scenario on my own rather than just seeing a few general ones.”


• step-by-step tutorials
• graphical display

Quiz Yourself: Interactive Simulations

These simulations use a step-by-step procedure in which the user inputs an answer for each step, and then checks the “solution box” to see the correct answer. The user then either continues to the next step or resets the simulation by selecting “new problem.” Different starting conditions are created when “new problem” is selected. Most steps have a “hint” box that can be selected. These simulations are useful for thermodynamics, separations, or material and energy balances courses. They follow the format used by Bansagi and Rodgers (Education for Chemical Engineers, 22, 27-34 (2018)) in their graphic web-apps. The first set of simulations are web based and can be used directly in a browser. The second set are CDF files that can be downloaded and used with the Wolfram CDF player.
40 Interactive self-study modules
http://www.learncheme.com/quiz-yourself/interactive-modules

- Overview, Before studying ..., After studying...
- ConcepTest, example problem (try to solve before study)
- Interactive screencasts, equations
- Interactive simulation with questions
- Quiz-yourself simulations
- Example problem screencasts
- ConcepTests
- Summary
Objectives

○ Incorporate self-testing
○ Try to solve before studying (desirable difficulties)

Interactive Self-Study Modules

Most modules include: introduction, Concept Tests, short introductory screencasts, important equations, interactive simulations with questions, quiz-yourself simulations, example problem screencasts, and summary.

Material & Energy Balances
- Ideal Gas Law
- Material Balances
- Steam Tables
- Raoult’s Law and VLE
- Humidity and Water-Air VLE

Single-Component Phase Equilibrium
- Single-Component Phase Diagrams
- Fugacity of a Single Component
- Chemical Potential
- Thermodynamic Properties Phase Diagrams
- Equations of State

Multi-Component Phase Equilibrium
- Raoult’s Law and VLE
- Le Chatelier’s Principle
- Fugacities of Mixtures
- Chemical Potential
- Vapour-Liquid Equilibrium for Non-Ideal Solutions
- Partial Molar Quantities
- Partially Miscible Liquids Phase Diagrams
- Immiscible Liquids Phase Diagrams
- Solid-Solid Liquid Phase Diagrams
- Using a Cubic Equation of State to Determine VLE

Chemical Reactions and Equilibrium
- Gas-Phase Chemical Equilibrium
- Heterogeneous Chemical Equilibrium
- Thermal Effects in Chemical Reactions

Energy Balances & Entropy
- State Functions
- First Law - Closed Systems
- First Law - Open Systems
- Steam Tables
- Reversible and Irreversible Expansion/Compression Processes
- Entropy
- Throttling and Joule-Thomson Expansion
- Turbines and Compressors
- Carnot Cycle
- Refrigeration Cycle
- Departure Functions

Separations
- Flash Separations
- Ternary Phase Diagrams
- Hunter Nash Method for Liquid-Liquid Extraction

Fluid Mechanics
- Buoyancy
- Bernoulli’s Equation
- Manometry
- Properties of Fluids

Kinetics
- Isothermal Batch Reactors
- Isothermal Continuous Stirred Tank Reactors (CSTRs)
- Isothermal Plug Flow Reactors (PFRs)
- Isothermal Semi-batch Reactors
- Multiple Steady States in a Non-Isothermal CSTR
73 students in thermodynamics
  o 70 modules useful/very useful
  o 35 very, extremely, etc.
  o 15 most useful/best part of course
  o 2 did not utilize
  o 1 not helpful

• I loved the self-study modules! They were very useful.
• Self-study modules are fantastic and one of the best aspects of the course.
• The interactive simulations were a lifesaver.
• They are great.
• Hugely helpful in every way and incredibly beneficial.
• The self-study modules are extremely useful.
• They are incredibly useful.
• The interactive self-study modules were the best part of the class
• I really, really like the interactive study modules.
3 Course packages in OneNote

Complete class materials to teach using active learning
Class note, suggested screencasts and simulations, assignments, exams, suggestions,

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Course Packages

These all inclusive digital OneNote notebook files contain class notes, ConceptTests, pre-class assignments, recommended screencasts and simulations, homework problems, sample exams and resources about active learning methods. They can be taught from directly or tailored to fit any instructor’s style.

**Available for:** Thermodynamics (updated: December 2015), Material and Energy Balances (updated: August 2015)

**Download:** Preview a sample of these materials in a [PDF](#).

**Instructors:** Contact us (LearnChemE@gmail.com) to obtain access.
