

CHEMICAL ENGINEERING SCREENCASTS

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We previously reported the advantages of using screencasts in chemical engineering courses.^[1] In the current paper we discuss uses of screencasts, describe their availability, present data that demonstrate how extensively they have been used, and provide additional student feedback. More than 430 screencasts have been prepared for seven chemical engineering courses: engineering calculations (computing), materials and energy balances, fluids, heat transfer, thermodynamics, kinetics/reactor design, and separations/mass transfer. Screencasts were prepared using Camtasia Studio 7 software,^[2] which captures both narration and real-time screen input. These screen recordings were edited and processed into MP4 videos that are posted online.

Two aspects of these videos make them appealing: most are 10 minutes in length or shorter, and they are not of professional quality. Because they are short, they maintain students' interest, and they also do not take much of an instructor's time to prepare. A large number of short screencasts gives an instructor flexibility. They are like a living set of notes an instructor can add to and remove material from, case by case. They can be used to explain any learning activity. Because they are not professional quality, the instructor does not have to do multiple takes. Instead, they are similar to a class presentation of the same material. The feedback indicates that students in a number of classes use them frequently and are overwhelmingly positive about them.

Screencasts allow instructors to be more efficient; for example, they don't have to repeat the same explanation multiple times in office hours. Instead, they can refer a student to one or

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Chapter 1: MOLE BALANCES

- 1.1 The Rate of Reaction
- 1.2 General Mole Balance Equation
- 1.3 Batch Reactors
- 1.4 Continuous-Flow Reactors
- 1.5 Industrial Reactors

Chapter 2: CONVERSION AND REACTOR SIZING

- 2.1 Definition of Conversion
- 2.2 Batch Reactor Design Equations
 - Isothermal Batch Reaction Part 1
 - Isothermal Batch Reaction Part 2
 - Solving O.D.E.s with POLYMATH**
- 2.3 Design Equations for Flow Reactors
 - Comparing CSTR and PFR Balances
- 2.4 Sizing Continuous-Flow Reactors
- 2.5 Reactors in Series
 - Comparing Reactors in Series
 - Determining CSTR Volumes in Series
 - Replacing a CSTR with 2 CSTRs
 - Sizing Two CSTRs in Series
 - Using Reciprocal Rate Data
- 2.6 Some Further Definitions

Chapter 3: RATE LAWS

Figure 1. Screenshot of <www.learncheme.com> website that show screencasts associated with the table of contents of Fogler's Essentials of Chemical Reaction Engineering.^[16]

more screencasts and ask him or her to return with questions. This allows an instructor to leverage his/her efforts by solving an example problem once and then referring the students to the video. Because the videos are short, they can be used as modules that provide a logical sequence for specific topics.

Previous studies have indicated the value of screencasts for improving student learning. Toto^[3,4] used 60 screencasts in a general chemistry class for distance learners. His screencasts addressed concepts from homework assignments on which students scored poorly the year before. Students with access to the screencasts scored 11% better in the course overall and 22% better on the difficult concepts on which prior students scored poorly. In addition, the students overwhelmingly liked the screencasts. Similarly, Stelzer, et al.,^[5-7] used web-based multimedia learning modules prior to class as an addition to, or even replacement for, the textbook. Student performance on questions assigned to be answered before class improved significantly when compared to those who did not have access to the videos.

The Khan Academy^[8] is a library that contains more than 2,400 screencast videos covering math, science, and other

topics. As explained on the website, "Each video is a digestible chunk, approximately 10 minutes long, and especially purposed for viewing on the computer." The website claims that more than 74 million lessons have been delivered. Pinder-Grover, et al.,^[9,10] used screencasts in a large materials science course, using both qualitative and quantitative approaches to assess the effectiveness of their approach. They found that overall performance was positively linked to screencast usage. Garrigus^[11] presented half of his lectures in the Texas public school system as screencasts, using the rest of the time for active learning. He found that class time was more efficient because he was able to engage the students in active learning and address individual student needs. Similarly, Bergmann and Sams pioneered a comparable approach, the "flipped classroom," which focuses on using screencasts instead of lectures.^[12] In this model, video lectures are assigned before class, allowing the teachers to spend more time during class working directly with students. Their flipped classroom approach has been adopted in schools worldwide.^[13]

Screencasts have also been used to train faculty and students to use educational technology. The Laurier Library^[14] developed a site to instruct faculty in the production of screencasts, including resources to create them at their own universities. Western Kentucky University has prepared screencasts as video tutorials for campus training technology for Human Resources and the Faculty Center for Excellence in Teaching, adopting the model from Bowers, et al.^[15] The University of Michigan library found that students who viewed instructional screencasts were able to not only complete a multi-step research process, but also able to apply concepts they learned to new situations.

CHEMICAL ENGINEERING SCREENCASTS

Available Screencasts

We have more than 430 screencasts posted on <www.learncheme.com> and on iTunesU and are continuing to add more. The thermodynamics and kinetics/reactor design courses have more than 120 screencasts each, and fluids and material and energy balances have more than 60. Screencasts are still being prepared for engineering calculations (computing), heat transfer, and separations/mass transfer; these courses have less than 30 screencasts each. The screencasts are organized by course topics and also by the tables of contents of commonly used textbooks for these courses. Figure 1 shows a screenshot from the website of part of the table of contents for Fogler's kinetics book.^[16] Links to screencasts useful for a chapter section are listed under that section. A short text summary description of the screencast content is displayed when a mouse pointer moves over a screencast link. The screencasts are in MP4 format and can be watched online or downloaded onto computers, tablets, and smart phones. They can also be viewed in or downloaded to iTunes from iTunesU (search for University of Colorado).

Screencast Applications

The screencasts on <www.learncheme.com> include:

- *Example problems: most of the screencasts are solutions to numerical problems similar to those found at the end of textbook chapters. As we switched our instruction to more active learning, particularly using ConcepTests, student-held clickers, and peer instruction,^[17-21] students requested more worked-out examples, and screencasts were prepared to address this request. These screencasts can be used to supplement or replace the example problems presented in conventional lecture-style courses.*
- *Exam reviews: for example, five screencasts that presented solutions to problems on previous final exams were made for review for a thermodynamics final exam instead of an evening exam review that has been used in the past. The class had 110 students, and each of these videos was watched almost 100 times. The students did better on the final exam than in previous years, so the screencasts were at least as effective as a live review.*
- *Software tutorials: screencasts are an effective way to explain the use of software.*
- *Explanations of how to use tables and graphs: for example, some screencasts explain how to use the steam tables to find properties of water, whereas others clarify phase diagrams or engineering charts.*
- *Explanations of confusing concepts or introductions to a topic: these are like mini-lectures.*

How Students Can Use Screencasts

Screencasts allow students to proceed at their pace so they can better understand the material, whereas instructors cannot go at a pace in class that is optimal for everyone. Students can also look at screencasts on their own schedule and they can play them more than once. They can stop and take notes and rewind; they can control the rate of information supplied to them. Thus, they have more control over their learning. Watching a screencast is more active than an in-class example.

Screencasts can be particularly useful for students who cannot attend office hours (*e.g.*, because of part-time jobs, extra-curricular activities, course conflicts) or students who need to refresh material from a prerequisite course. Students are sometimes poorly prepared for a course, especially when they took the prerequisite courses more than a year earlier. Screencasts provide a way for them to review at the beginning of the semester. Similarly, some graduate students do not have undergraduate degrees in chemical engineering, and screencasts might help prepare them for graduate classes. Some of our seniors take the Fundamentals of Engineering (FE) exam, which includes topics they may not have seen for two or three years. Screencasts are an effective way to reach a larger number of students than could attend a review session. Thus, screencasts are also organized by the topics in the FE exam on the website.

Student feedback

We have used screencasts for three years, in courses ranging from freshman chemistry to graduate-level kinetics, and the feedback has been overwhelmingly positive. Some typical anonymous comments at the end of the semester from students in a thermodynamics course in Fall 2010 were:

- “Screencasts helped me understand concepts that I wasn’t completely comfortable with.”
- “The screencasts were the best thing that helped me learn in this course.”
- “The screencasts help tremendously in providing good explanations.”
- “The screencasts were extremely helpful for understanding material and preparing for exams.”
- “The screencasts are also VERY helpful for homework and study. I use them a lot!”
- “Screencasts helped a LOT!”
- “I really like the screencasts; they help me learn the most.”

The responses to the question at the end of the Fall 2009 semester in thermodynamics, “How useful have you found the screencasts (videos) as a learning tool?” were also very positive, with 72% of the respondents saying they were useful or very useful. Feedback from 62 students in the Spring 2011 fluids course was similar: More than 91% of the students found them useful to very useful. The number of students who used the screencasts frequently (10 or more times) was high, and more than half the class claimed to have watched over half the screencasts.

One indication of the value of the screencasts is the number of times they have been played. We first posted screencasts online in August 2010 and gradually increased the number to more than 430. As shown in Figure 2, the number of

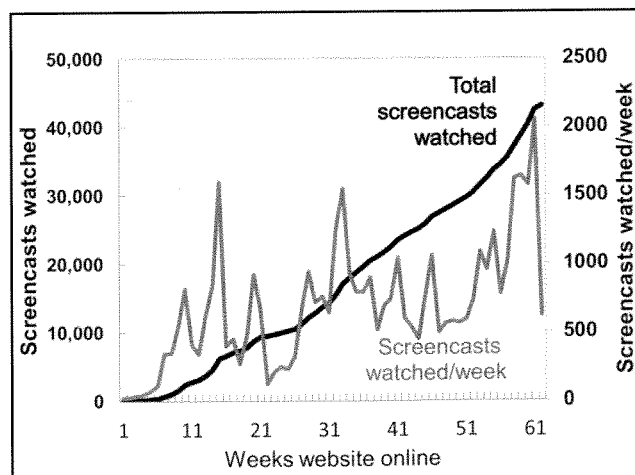


Figure 2. Number of screencasts watched per week and total number of screencasts watched since initially posting screencasts online.

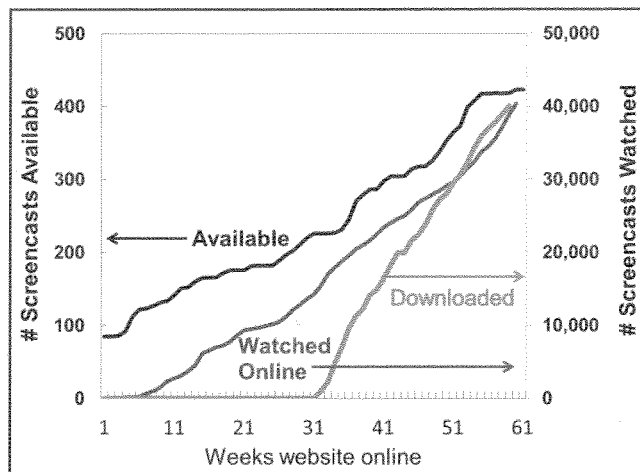


Figure 3. Number of screencasts available online, watched and downloaded from both <www.learncheme.com> and iTunesU.

screencasts watched each week varies widely, with some of the maxima corresponding to exams during the semester and to final exams. The screencasts have been played more than 43,000 times as of September 2011. In March 2011 (week 31 in Figure 2) the screencasts were also added to iTunesU, which allows them to be watched online or downloaded for offline use. As shown in Figure 3, in less than 28 weeks over 41,000 screencasts were downloaded, so that these screencasts were either watched or downloaded more than 84,000 times.

Planned Additions/Improvements to the Website

Screencasts are still being added to the website, with the goal of at least 75 screencasts for each of the courses. Biological engineering examples are also being added since most chemical engineering programs have a significant biological emphasis. We also plan to try an open forum in our courses to get feedback on aspects that are unclear or incorrect so that modified screencasts can be prepared.

PREPARING SCREENCASTS

An example problem solution presented in a screencast can potentially be more effective than a similar problem in a book. Detailed narration can be provided without a lot of preparation time. The screencast can emphasize what are known to be confusing aspects and point out common mistakes. It can also demonstrate a problem-solving format and demonstrate the types of solutions expected on homework assignments.

A 10-minute screencast of the solution to an example problem might take 30-40 minutes of the instructor's time to prepare, assuming the solution and calculations are already complete. An approach that we have found effective^[22] includes the following:

- Prepare a rehearsal script of exactly what will be included in the screencast. Include notes on points to emphasize.

- Start the screencast stating its purpose.
- Pause while recording to make the screencast shorter. Equations can be written, a diagram can be drawn, or numbers can be multiplied during the pause and the result explained when the recording restarts.
- Record the screencast as if presenting a problem solution in class, with all the attendant pauses, hesitations, dead times, and external noises.
- Follow a problem-solving outline: start with diagrams, label knowns and unknowns, use units throughout, make assumptions explicit, check solutions at the end, and so forth.
- Repeat a section if a mistake is made, rather than starting the recording over.
- Remove the errors and dead times after the recording is complete. This can be done by an undergraduate student assistant. Note that the dead times and other extraneous parts can be left in without compromising the screencast.
- Add highlights, annotations, and call-outs post-recording to focus a student's attention. This can be done by a B.S. level chemical engineer. These are not necessary, but highlighting can help minimize confusion, and call-outs can provide alternate explanations, definitions, or references to other materials.
- If the screencast looks like it will be longer than 10 minutes, break it into two screencasts.

The cost for software and hardware to prepare screencasts is low. Tablet PCs cost less than \$1,000 and Camtasia Studio 7,^[2] which was used to record all screencasts on our website, costs less than \$300. Other screen capture programs can be used,^[23] but Camtasia is simple to learn, user-friendly, and has editing tools that can enhance the quality of the screencast.

SUMMARY

Over 430 screencasts have been prepared and disseminated online for seven core chemical engineering courses, and more are being added weekly. These screencasts are organized for each course by topic and also by textbooks' tables of contents. They have been played more than 43,000 times and downloaded 41,000 times. Student feedback has been extremely positive. Screencasts were prepared that present solutions to example problems, exam reviews, explanations on how to use software, and mini-lectures that introduce a topic or explain a concept. Suggestions were offered on how to produce screencasts. We encourage faculty to consider using the screencasts on <www.learncheme.com> as part of their courses or informing their students of the screencasts' availability so they can decide if the screencasts are useful.

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