AC 2012-5025: INCORPORATING SCREENCASTS INTO CHEMICAL ENGINEERING COURSES

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

Janet deGrazia is a Senior Instructor in the Chemical and Biological Engineering Department at the University of Colorado. She teaches a number of courses in the department, including a course on technology for non-engineers. As Chair of the Undergraduate Committee, her interests lie in curricular innovations and the use of technology in education. She received her Ph.D. from the University of Colorado in chemical engineering.

Dr. John L. Falconer, University of Colorado, Boulder
Dr. Garret Nicodemus, University of Colorado, Boulder
Dr. Will Medlin, University of Colorado, Boulder

Incorporating Screencasts into Chemical Engineering Courses

How would you like to have this kind of feedback from your students? " they are fantastic", "they are amazing. ", "I love them", "They are very VERY helpful," "I think that they were unbelievably effective….." "They were extremely helpful for understanding material and preparing for exams" when surveying students about certain teaching methods? This is the kind of response that we have received from students about our screencasts. This enthusiastic student feedback, coupled with current research that supports the use of screencasts for enhanced student learning, has led us to expand our inventory of screencasts and widely disseminate them.

Screencasts are short videos (less than 10 minutes) with narration and are made by digital capture of a tablet PC screen. Screencasts can be used by faculty to supplement their current teaching style, since they are equivalent to what an instructor might present on the board during class. They can be used in combination with textbooks, online reading quizzes, homework assignments, office hours, and exams. They can also be used to create flipped classrooms, where students work under the supervision of the instructor during class, and information delivery is outside of class[1,2]. They are brief enough to hold students' attention, but complete enough to address a course learning objective. Screencasts can be introductions to a topic, solutions to example problems, explanations of concepts, software tutorials, exam reviews, or mini-lectures. Learning has been reported to be enhanced when learners study carefully worked out examples instead of attempting to do the problems themselves[3]. Learners have easy and immediate access to these instructional materials on their own time.

We have created an inventory of over 525 screencasts in eight chemical engineering courses (thermodynamics, kinetics, materials & energy balances, fluids, separations, material science, heat transfer, and engineering computing), as well as solutions to example problems for the Fundamentals of Engineering exam. These screencasts are posted on www.learnchem.com, iTunes U, and YouTube (www.youtube.com/ learncheme). On the learnchem.com site, they are organized by tables of contents of commonly-used textbooks. The response has been excellent. Our screencasts were viewed (or downloaded from iTunesU) over 150,000 times in 2011, with more than 30,000 views in December alone. Uploading the screencasts on YouTube at the end of November increased the number of plays significantly; they almost tripled in three months. Some of our most popular screencasts have been exam reviews.

Our approach for preparing screencasts is to keep them short, animate our voices, stick to one objective, tell the students what they will learn, and stay on topic. In addition we are using principles developed from research studies on learning with multimedia[4,5]. These include:
   a) Use visual representations that illustrates relationships among content
   b) Avoid decorative visuals that do not contribute to instructional goals
   c) Reduce the cognitive load
   d) Describe complex visuals with audio only to avoid overloading the visual centers of the working memory
   e) Use first and second person pronouns – learners tend to process more deeply in a social-like setting
   f) Minimize the script by only using essential content that supports learning goals

How do screencasts differ from other learning materials?

Recordings of 50-minute lectures are available online (iTunesU, YouTube) for some engineering courses, but screencasts differ significantly from recorded lectures and textbooks:

- Screencasts are short so they hold students' attention, they do not show an instructor, and they do not contain extraneous material, all of which are advantages for learning[4,5]. They present only one topic, and thus students are less likely to be confused than with a textbook or lecture.

- They are developed for students to use on their own, independent of a given textbook and its notation. They stand alone, and generally do not require that another screencast be watched first. The notation is explained in each screencast, and solutions are presented in detail.

- The screencast preparer can scroll back to a figure to point out something, and material can be sequenced in time (e.g., a diagram presented one line at a time to clearly indicate solution steps, whereas putting ten versions of a figure in a textbook is not practical). Screencasts can include suggestions of things to be aware of (e.g., be careful to use absolute temperature) and common misconceptions, as is often done in class or office hours, but less often in textbooks.

- Screencasts are modular, so a faculty member or student can use the ones of interest and in whatever order they wish. They essentially allow a user to choose their course content independent of the textbook, leading to broader dissemination.

Advantages of screencasts

Screencasts have significant advantages over textbooks or class presentations as they:

- are short and highly focused, so they will be used more than a 30-40 minute video.

- allow instructors to use class time for active learning (e.g., ConcepTests, clicker questions, peer instruction, group exercises) since information delivery is outside the classroom.. They can be used with flipped classrooms[1,2], where students view 4 or 5 screencasts before class and complete an online quiz. They can also be used to supplement a lecture style course.

- are dynamic with visuals, narration, written words, and diagrams, and they are sequential in time, which is often better than static written text. In textbooks, diagrams and the referring text are in different locations on a page, and if these cannot be understood independently, significant demands are placed on working memory[6]. Screencasts present diagrams and verbal explanations at the same time, which has been shown to enhance learning[5].

- enhance learning by giving students control over their learning; students control the rate they receive information and when they watch them. Students can pause to take notes and then go back to screencast; in contrast, in classroom lectures, students ineffectively try to take notes while the instructor continues to lecture. Instructors cannot go at a pace in class that is ideal for everyone, but students can stop, rewind, and replay a screencast so students control the pace. Also, screencasts allow students to expand their learning time more easily than lectures.

- are easily adopted by other departments because the infrastructure for using videos (YouTube, mobile phones, tablets, etc.) already exists, and thus special software is not

required. Instructors can create links to screencasts on their own web page or course management system and organize them to fit their course.

- are sustainable; once prepared, they do not require maintenance. They are flexible; new screencasts can be produced, corrections can be made, and clarifications can be added.
- address the needs for many different types of students. Commuter and low-income students who work, care for children, etc., and cannot attend office hours can obtain the additional information when it is convenient. Screencasts can also provide review material from pre-requisite courses for students who are not well-prepared.

Recent research[7] suggests that a multifaceted approach to education enhances learning. Recommendations include replacing traditional lectures with interactive instruments supplemented with technological tools to heighten learning. However, many instructors find it difficult to make changes in their teaching styles because of a lack of time or resources. To overcome this hurdle, we have made screencasts available for their introduction into chemical engineering classes. Some faculty have expressed concerns that devoting time in class to active learning might not provide students with sufficient examples of problem solving or sufficient time to introduce material; screencasts can supplement the classes to overcome these concerns.

One interesting result showed that screencasts can change the students' perception of a course. Stelzer et al.[8] used web-based multimedia learning modules (similar to screencasts) as pre-lectures for a physics course. They saw a modest increase in exam performance, and student responses to online questions before class indicated that they were significantly better prepared for class compared to simply assigning textbook reading. More significant were the changes in student attitudes. Previously, this course was rated as one the most difficult on campus by 78% of the students, but this dropped to 43% when pre-lectures were used. Also, the percentage of students who had a positive attitude towards physics increased from 39% without pre-lectures to 75% with pre-lectures. They said the drop in perceived difficulty was consistent with students spending less time preparing for exams.

In addition, the meta-analysis study by the Department of Education[9] found that students in courses that used both online learning and face-to-face instruction performed better than students with only face-to-face instruction. Students with completely online learning course also performed modestly better than those receiving face-to-face instruction. This study concluded that a combination of elements resulted in additional learning time, and the additional time produced the increased learning. They stated: "Online learning is more conducive to the expansion of learning time than is face-to-face instruction."

Because students really like screencasts, they watch them even if they are not assigned, and thus they spend more time on the material. The feedback indicates that students think they are valuable. As we reported[10,11], responses in our classes have been overwhelmingly positive. Other examples of student feedback are: "They are a useful way to gain more guided practice, in addition to what we learn in class. The major benefit for me is that they are available 24/7, cover a range of topics in all of our classes, and present problems that we haven't seen before." "Instead of passively reading an example problem on my own, screencasts are not only another valuable learning resource, but also can actively involve me in problems and concepts in a more engaging medium that incorporates the guidance and insights of an instructor." The research

shows that screencasts are a valuable teaching tool, and the encouraging comments from our students indicate that they use them and will continue to do so, thereby contributing to their own education and enhancing the effect of the learning experience.

1. J. Bergmann, A. Sams, The Flipped Classroom Blog, http://blendedclassroom.blogspot.com/

2. J. Bergmann, A. Sams, Remixing the Chemistry Class, *Learning and Leading with Technology* 1, 22 - 27 (2008).

3. J. Sweller, J.J.G. van Merrienboer, F.G.W.S. Paas, Cognitive Architecture and Instructional Design, *Ed. Psych. Rev.,* 10, 251-296 (1998)

4. R.C. Clark, Leveraging multi-media for learning: Use instructional methods proven to align with natural learning processes, Adobe Systems Inc. White Paper (2007)

5. R.C. Clark, R.E. Mayer, e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning, John Wiley and Sons, San Francisco (2011)

6. D.A. Muller, *Designing Effective Multimedia for Physics Education,* PhD dissertation, University of Sydney, Australia (2008)

7. M.S. Donovan, J.D. Bransford, J.W. Pellegrino, *How People Learn: Bridging Research and Practice*, National Academy Press, Washington D.C., 1999

8. T. Stelzer, D.T. Brookes, G. Gladding, J.P. Mestre, Impact of multimedia learning modules on an introductory course on electricity and magnetism, *Am. J. Phys.* 78, 755 (2010).

9. B. Means, Y. Toyama, R. Murphy, M. Bakia, K. Jones, Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies, U.S. Department of Education (2010). http://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf

10. J.L. Falconer, J. deGrazia, J.W. Medlin, M. Holmberg, Using Screencasts in Chemical Engineering Courses, *Chem. Eng. Ed. 43*, 302-305 (2009).

11. J.L. Falconer, G. Nicodemus, J. deGrazia, J.W. Medlin, Chemical Engineering Screencasts, *Chem. Eng. Ed.***,** in press (2011).