

# A Review of Educational Computer Simulations for Interactive Lecture Demonstrations in Introductory Astronomy Survey Courses

Schwartz, Andria C.; French, Debbie; Gutierrez, Joseph; Sanchez, Richard A.; Slater, Timothy F.; Tatge, Coty

Presented at the NES-AAPT, Spring 2014

<http://physics.uwyo.edu/~aschwartz/>

**Interactive Lecture Demonstrations (ILDs)**  
Instructional Sequence:  
1. Set Up  
2. Think  
3. Pair  
4. Share  
5. Commit  
6. See It  
7. Agree  
8. Transfer  
(adapted from Sokoloff & Thornton 1997, 2004)

**Example:** Which ball will hit first, dropped vertically or shot horizontally?

**Benefits of ILDs**

- Peer instruction – students learn better through helping each other (Crouch & Mazur, 2001; Lasry, et al., 2008)
- Committing to an answer requires students to explicitly state their reasoning (Sokoloff & Thornton, 1997)
- Active engagement – interacting with the material helps students to internalize it (Hake, 1998; LoPresto, 2012)

**Overview**  
Physics instructors have long used demonstrations during lecture time (Sokoloff & Thornton 1997). Astronomy instructors on the other hand have been largely unable to implement tangible demos due specifically to the nature of the content. Many science courses have made extensive use of educational computer simulations, but the setting for these has typically been during labs or as homework assignments where students can each interact with the software individually or in small groups (e.g., Finkelstein, et al., 2005; Meier, et al., 2008). Simulations for astronomy instruction exist (Lee & Slater, 2006), but have not been extensively implemented or studied in astronomy lecture settings.

- ILDs have research-based learning advantages, such as active engagement and peer instruction
- ECSs allow demonstrations of astronomy topics of which we can't do tangible demonstrations
- Few studies of using ECSs as ILDs exist

**Educational Computer Simulations (ECSs)**

- Represents a real situation in which things happen.
- User has controls over the problem or situation.
- Omits distracting/irrelevant variables for the instructional goals.  
(adapted from Gagne 1962, as quoted in Lunetta & Hoffstein 1981)

**Example:** What will happen to a star's spectrum when it gets hotter?

**Benefits of ECSs**

- Better learning improvement than no instruction (Cox, et al., 2005), lecture (McKagan, et al., 2008), worked problems (demonstrations of how to solve problems, Lee, et al., 2004), tangible labs (Finkelstein, et al., 2005)
- Better transfer – application of learning to new situations (Koops & Hoenaar, 2012; Meier, et al., 2008)
- Potential for reduced cognitive load – omitting irrelevant aspects allows students to focus on the important parts

**ILDs vs ECSs Venn Diagram:**

- ILDs only:** Tangible Demonstration, Commit to an Answer
- Intersection:** Active Participation, Peer Instruction, Increased Gains
- ECSs only:** Improved Transfer, Reduced Cognitive Load, Computer Skills

**Next Steps**

- Design student prediction sheets for astronomy ILDs using ECSs
- Design instructor guide
- Pilot study of these materials
- Revise as necessary

**Final goal**

- Student workbook with response sheets
- Instructor guide with links, tips, etc.
- Available free via CAPER website and email list
- Published for wider dissemination

Full references available at <http://physics.uwyo.edu/~aschwartz/>

**CAPER Team**  
Center for Astronomy and Physics Education Research

## References

- Cox, Anne J., Mario Belloni, and Wolfgang Christian. 2005. "Teaching Physics with Physlet®-Based Ranking Task Exercises." *The Physics Teacher* 43 (9) (December 1): 587. doi:10.1119/1.2136455.
- Crouch, Catherine H., and Eric Mazur. 2001. "Peer Instruction: Ten Years of Experience and Results." *American Journal of Physics* 69 (9) (September 1): 970. doi:10.1119/1.1374249.
- Finkelstein, N., W. Adams, C. Keller, P. Kohl, K. Perkins, N. Podolefsky, S. Reid, and R. LeMaster. 2005. "When Learning about the Real World Is Better Done Virtually: A Study of Substituting Computer Simulations for Laboratory Equipment." *Physical Review Special Topics - Physics Education Research* 1 (1) (October): 010103. doi:10.1103/PhysRevSTPER.1.010103.

- Hake, Richard R. 1998. "Interactive-Engagement versus Traditional Methods: A Six-Thousand-Student Survey of Mechanics Test Data for Introductory Physics Courses." *American Journal of Physics* 66 (1): 64. doi:10.1119/1.18809.
- Koops, M., and M. Hoevenaar. 2012. "Conceptual Change During a Serious Game: Using a Lemniscate Model to Compare Strategies in a Physics Game." *Simulation & Gaming* 44 (4) (September 24): 544–561. doi:10.1177/1046878112459261.
- Lasry, Nathaniel, Eric Mazur, and Jessica Watkins. 2008. "Peer Instruction: From Harvard to the Two-Year College." *American Journal of Physics* 76 (11) (November 1): 1066. doi:10.1119/1.2978182.
- Lee, Kevin (University of Nebraska - Lincoln). 2013. "Astronomy Simulations and Animations (UNL)." <http://astro.unl.edu> NSF grants #0231270, #0404988
- Lee, Kevin M., Gayle Nicoll, and David W. Brooks. 2004. "A Comparison of Inquiry and Worked Example Web-Based Instruction Using Physlets." *Journal of Science Education and Technology* 13 (1) (March): 81–88. doi:10.1023/B:JOST.0000019640.07432.2b.
- LoPresto, Michael C. 2012. "Comparing Modern Methods of Active & Collaborative Learning & Learner-Centered Teaching to Traditional Lectures."
- Lunetta, Vincent N., and Avi Hofstein. 1981. "Simulations in Science Education." *Science Education* 65 (3) (July): 243–252. doi:10.1002/sce.3730650302.
- McKagan, S. B., K. K. Perkins, M. Dubson, C. Malley, S. Reid, R. LeMaster, and C. E. Wieman. 2008. "Developing and Researching PhET Simulations for Teaching Quantum Mechanics." *American Journal of Physics* 76 (4) (April 1): 406. doi:10.1119/1.2885199.
- Meier, Debra K., Karl J. Reinhard, David O. Carter, and David W. Brooks. 2008. "Simulations with Elaborated Worked Example Modeling: Beneficial Effects on Schema Acquisition." *Journal of Science Education and Technology* 17 (3) (March 25): 262–273. doi:10.1007/s10956-008-9096-4.
- Slater, Timothy F, and Kevin M. Lee. 2006. "Leveraging Conceptual Frameworks to Improve Students' Mental Organization of Astronomy Understanding." *Bulletin of the American Astronomical Society* 38: 98.
- Sokoloff, David R., and Ronald K. Thornton. 1997. "Using Interactive Lecture Demonstrations to Create an Active Learning Environment." *The Physics Teacher* 35 (6): 340. doi:10.1119/1.2344715.
- — —. 2004. *Interactive Lecture Demonstrations: Active Learning in Introductory Physics*. 1st ed. Danvers, MA: John Wiley & Sons.