**Using PhET Interactive Simulations in College Lecture**

Ideas for engaging students through inquiry in lecture settings

**University of Colorado’s PhET Project** has developed over 100 interactive simulations for teaching and learning science. These simulations provide animated, interactive, and game-like environments which enable scientist-like exploration. They emphasize the connections between real-life phenomena and the underlying science, make the invisible visible (e.g., atoms, molecules, electrons, photons), and include the visual models that experts use to aid their thinking. More, including examples, at [http://phet.colorado.edu](http://phet.colorado.edu)

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**Visual Aids and Demos**

By using sims as an animated illustration, instructors find that it is easier to communicate effectively with their students. The sims show dynamic processes and these can be slowed down, sped up, or paused, depending on the concept being shown; the invisible is made visible; and multiple representations are linked. Finally, the sims are easily adjusted by the instructor during the discussion. These features often make sims more effective for learning and more practical to use than static drawings or live demos.

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**Student-driven Discussions**

PhET is designed to help students develop science inquiry skills by exploring cause-and-effect relationships. Instructors can facilitate whole-class inquiry by creating a scenario in the simulation, and asking students to predict the effect of manipulating variables. In such classrooms, students often spontaneously ask many more, and deeper questions. It is common for students to ask a series of “what-if” questions and direct the teachers’ use of the sim.

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A short demo of charge transfer and polarization with *Balloons and Buoyancy* generates a series of student questions:

*If you rub the sweater on the balloon* (rather than balloon on sweater) *will electrons transfer the other way?*
*Can you polarize something where the protons move?*
*Are there any situations in which the +’s move?*

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The *Radio Waves* sim helps faculty communicate ideas about: creating electromagnetic waves, oscillating electric field strength, and the speed of light.

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An in-class question at right resulted in a class-led “what if” exploration with the *Circuit Construction Kit.* (Only 25% correctly answer D)

Students say:
*I don’t get it. It’s a closed circuit.*
*Can you explain one more time why Bulb A doesn’t light?*
*What if that battery is increased in voltage?*
(Instructors say “let’s try it. Which way will current flow?”)
*What happens to Bulb B current? Does it get brighter?*
*What happens if you flip one (of the batteries) over?*

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The light bulbs in the circuit are identical. When the switch is closed.
## Concept or “Clicker” Questions

Concept tests give students an opportunity to discuss and make sense of concepts related to the simulation.

1. ** Pose question**
2. **Student-student discussion**
3. **Vote**
4. **Follow-up discussion**

### Strategies for Writing Questions*

1. Predict an outcome of an “experiment” with the simulation (e.g., what will happen if? Which change in the sim setup would result in the desired behavior?)
2. Rank cases (e.g. which bulb will be brightest).
3. Compare contrasting cases (e.g., two different waves)
4. Interpret different representations (e.g. graphs, pictures, vectors).
5. Connect to real-world applications

*adapted from Beatty et al., AJP, 2006

## Interactive Lecture Demos (ILDs)*

ILD’s increase student learning from demos by having students actively identify expectations, and resolve any inconsistencies.

1. **Pose scenario**
2. **Students make individual predictions**
3. **Student-student discussions.**
4. **Revise predictions.**
5. **Instructor elicits predictions and reasoning**
6. **Instructor conducts “experiment” with simulation**
7. **Students record result and how different from prediction.**
8. **Whole class discussion with student participation.** Focus on reasoning.