PhET Interactive Simulations

Effective classroom use

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U. Colorado at Boulder

Physics Dept

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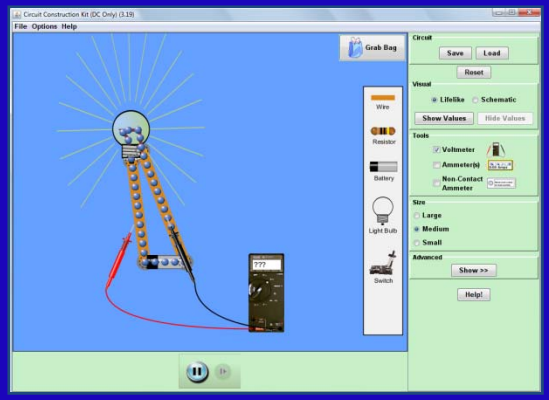
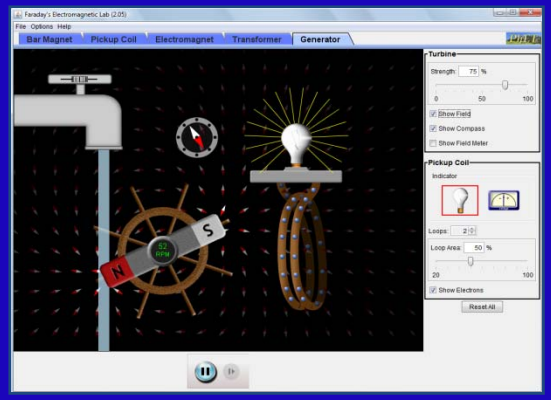
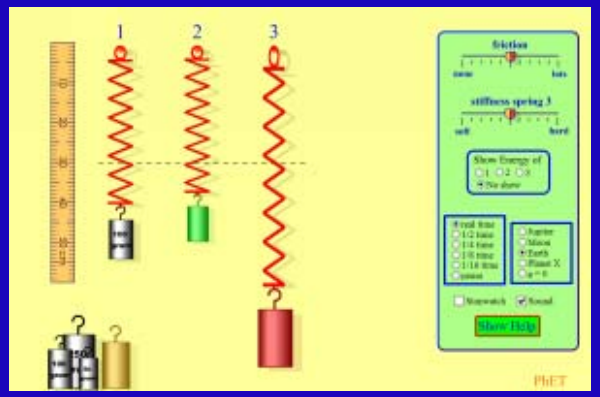
What is PhET?

Originally, the Physics Education Technology project.

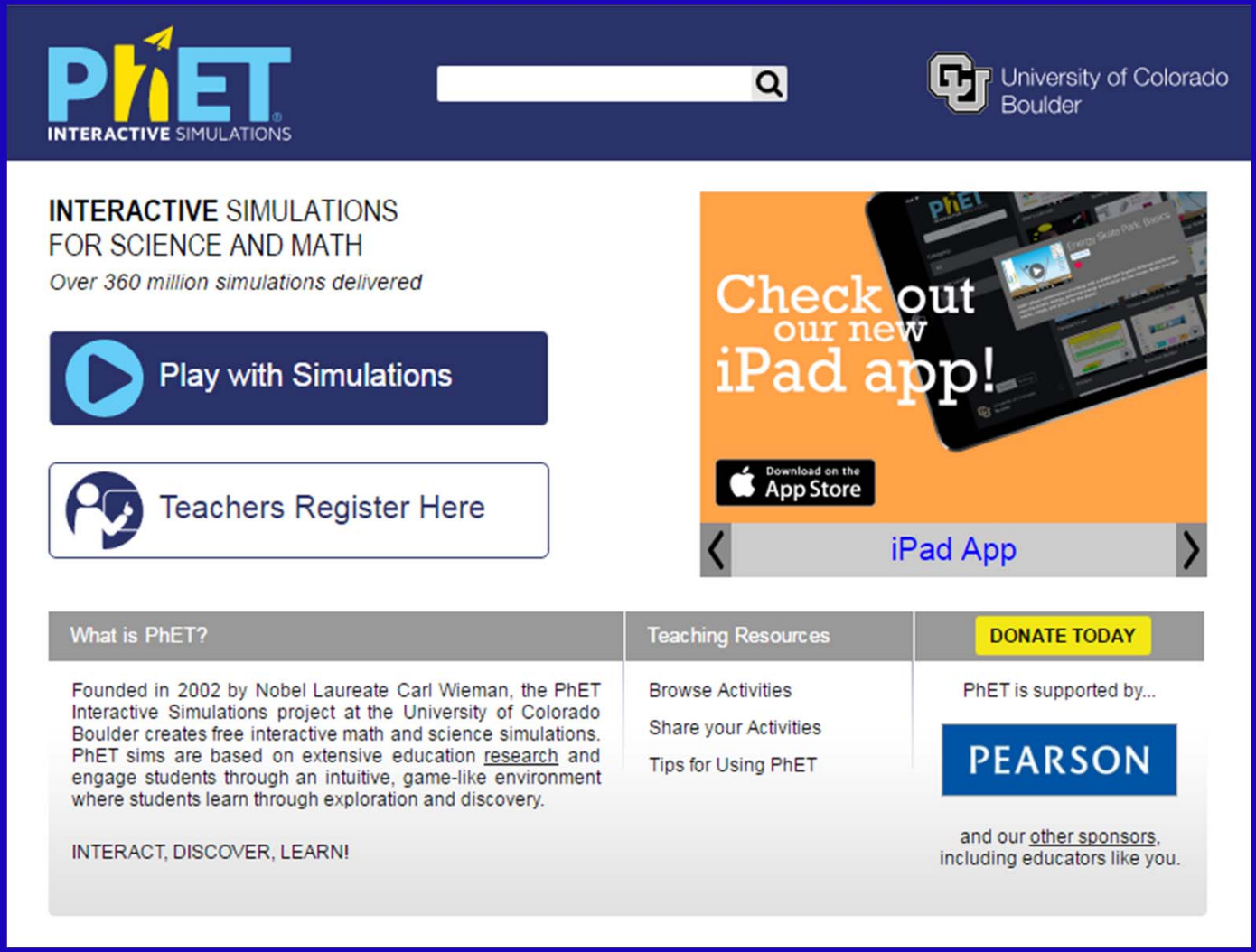






- Suite of **>100** interactive sims for science education.
- Research-based and user-tested.
- HTML5, Flash, and Java, run in browser or offline.
- Physics, Math, Chemistry, Earth Science, Biology.
- All FREE. Source code available.

Where is PhET?



http://phet.colorado.edu

Examples:

- Circuit Construction kit.
- Masses and Springs.

Who is PhET?

Founded by Carl Wieman, 2002

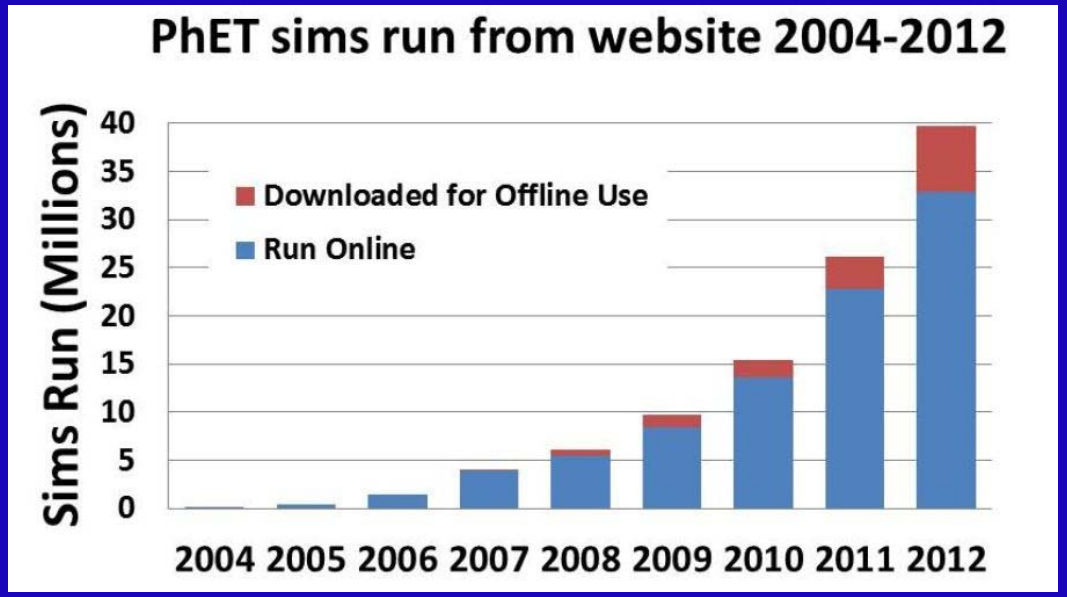
Part of the Physics Education Research Group at CU Boulder

University faculty, post-docs,
K-12 teachers, software developers

Prof. Kathy Perkins, CEO, education researcher, and grant-getter *extraordinaire*

Accessible

- Open-use License: Creative Commons - Attribution
- Easy to translate for World-wide Use:
  Over 2700 translations in 59 languages,
  34% of use outside US
- > 100 million sims run last year

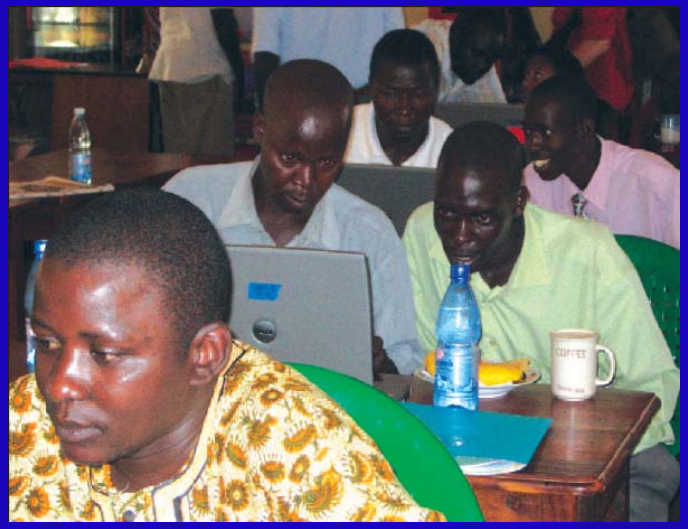


PhET around the world

Serbia

Brazil

Vietnam



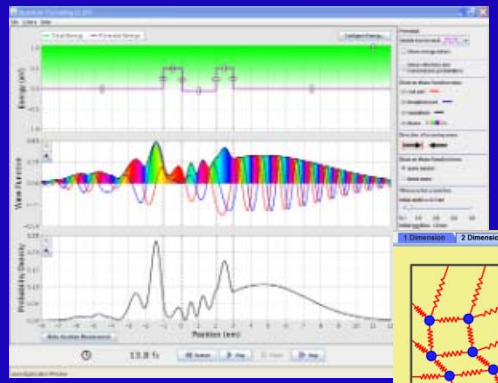
Uganda

What is PhET's intended audience?

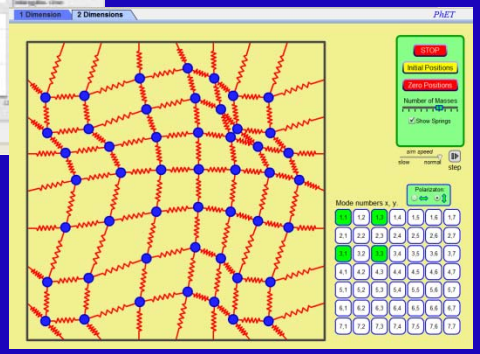
- Originally, college freshmen, physics sims
- Now, grade school through grad school
  sims are physics and math,
  many chemistry, some earth science and biology

Arithmetic Workout

Build an Atom



QM Tunneling



Normal Modes

How might you use these sims in your school?

Designed for versatile use

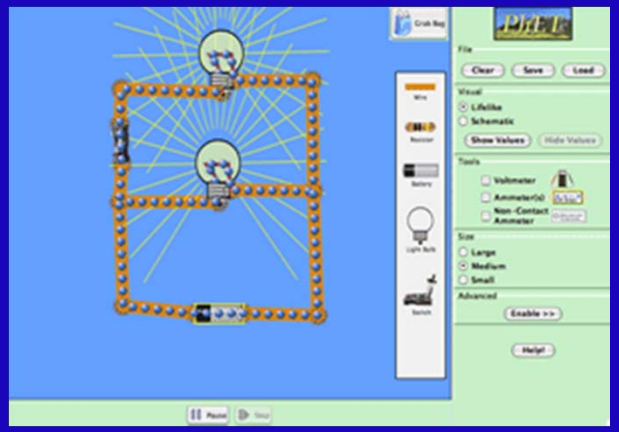
- Pre-lecture assignment
- Interactive Lecture Demonstration
- Clicker Questions
- In-class activity
- Lab or Recitation
- Homework

No silver bullet: context and activity critical

Versatile!

- Flexibility for you to
  - ✓ Pick and choose which sims to use
  - ✓ Customize use …
    to <u>your</u> environment and <u>your</u> learning goal
  - ✓ Search database of activities (>500 by PhET or Teacher-users)

Circuit Construction Kit



CCK in grade school:

"Make the light bulb light"

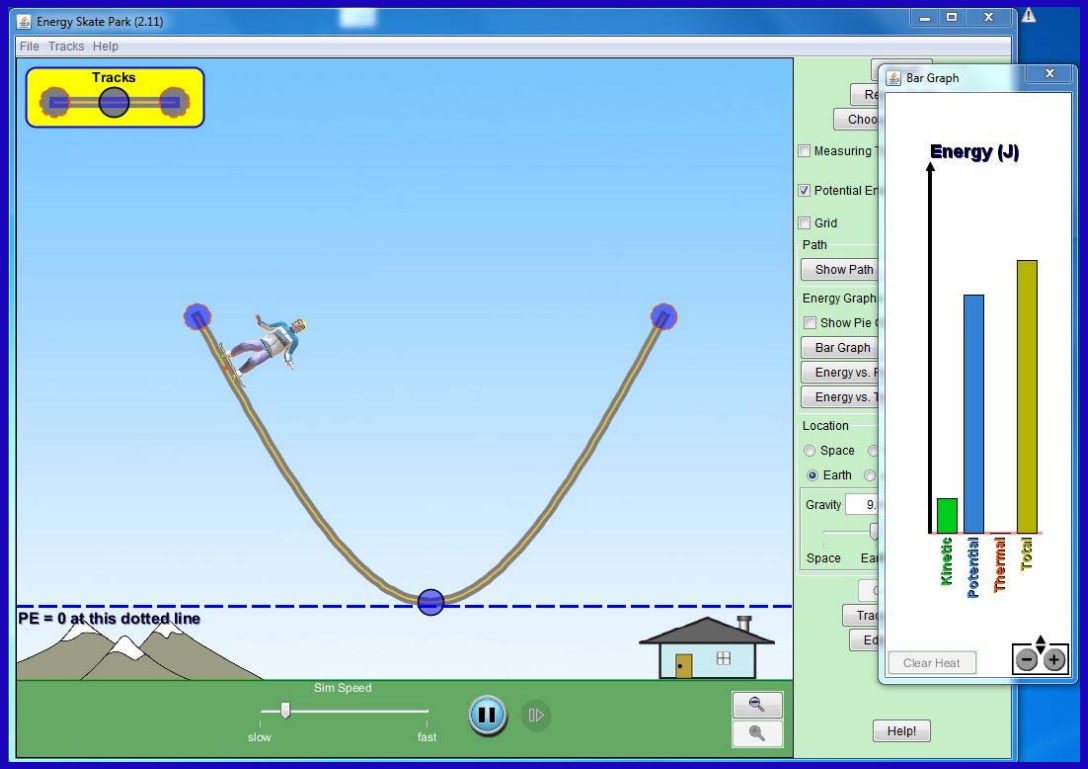
CCK in college:

"Explain why the light dims when you turn the heater on"

Examples:

- Friction
- Energy Skate Park

Example: Concept Tests

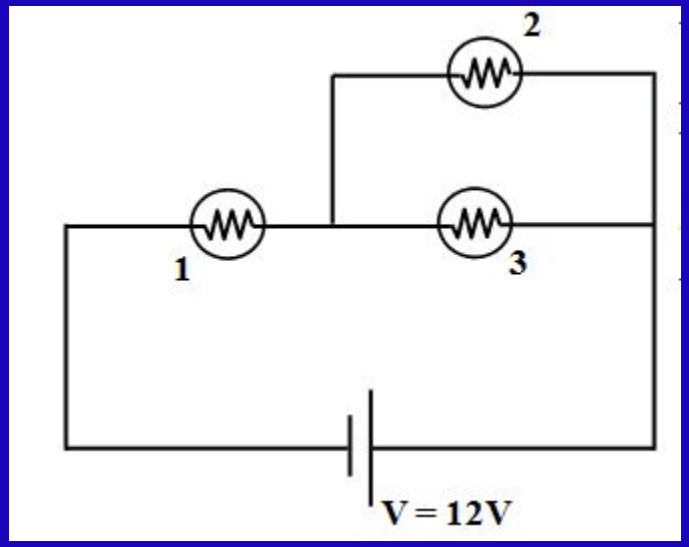


I move the zero of PE up to the starting point of the Skateboarder (skateboarder still starts from rest).

The total energy of the system is now:

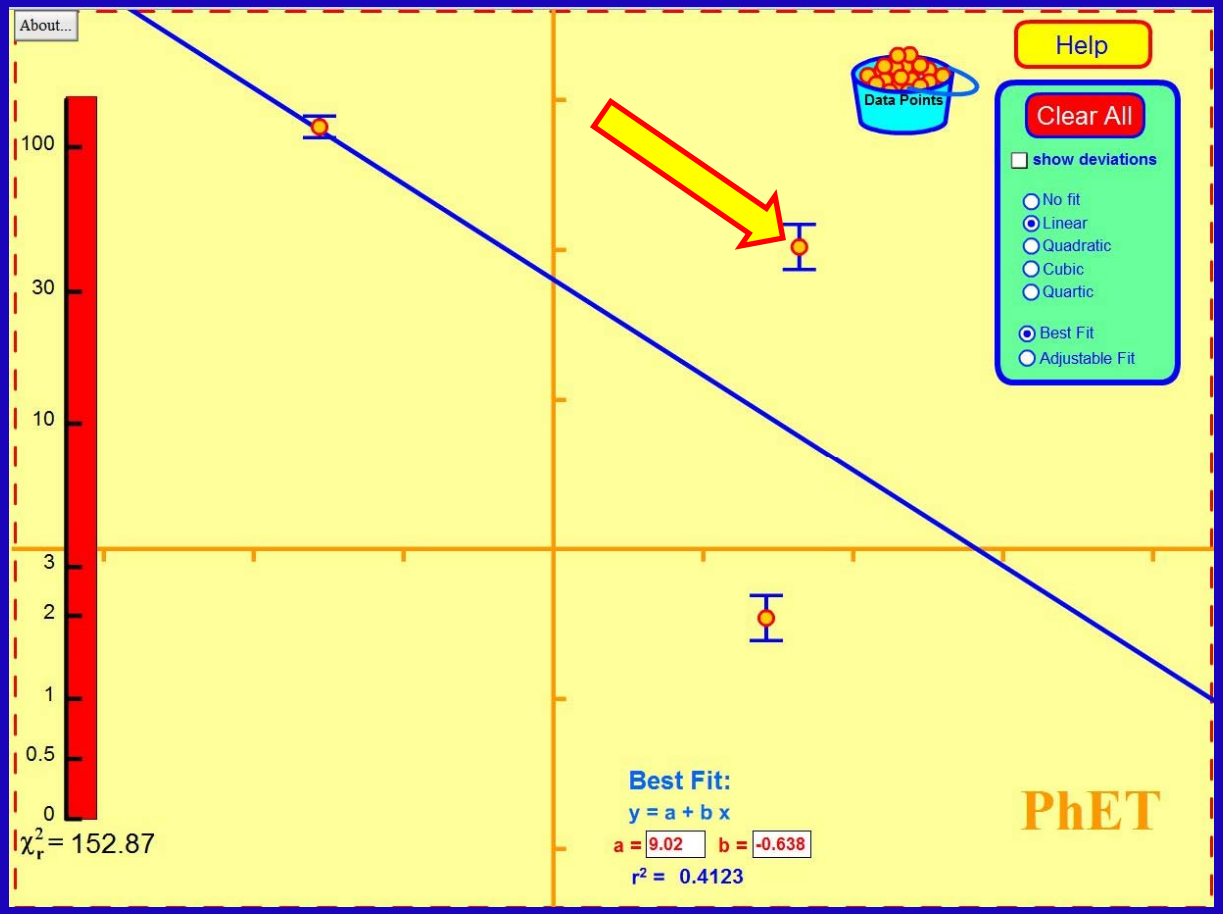
A) Zero B) positive C) negative

D) Depends on the position of the skateboarder



In the circuit, what happens to the brightness of bulb 1, when bulb 2 burns out? (When a bulb burns out, its resistance becomes infinite.)

A) Bulb 1 gets brighter
B) Bulb 1 gets dimmer.
C) Its brightness remains the same.
(Hint: What happens to the current from the battery when bulb 2 burns out.)



If we increase the error bar on the date point shown, what happens to the slope of the best-fit line?

A) It becomes more negative (line tilts CW).

B) It becomes less negative (line tilts CCW).

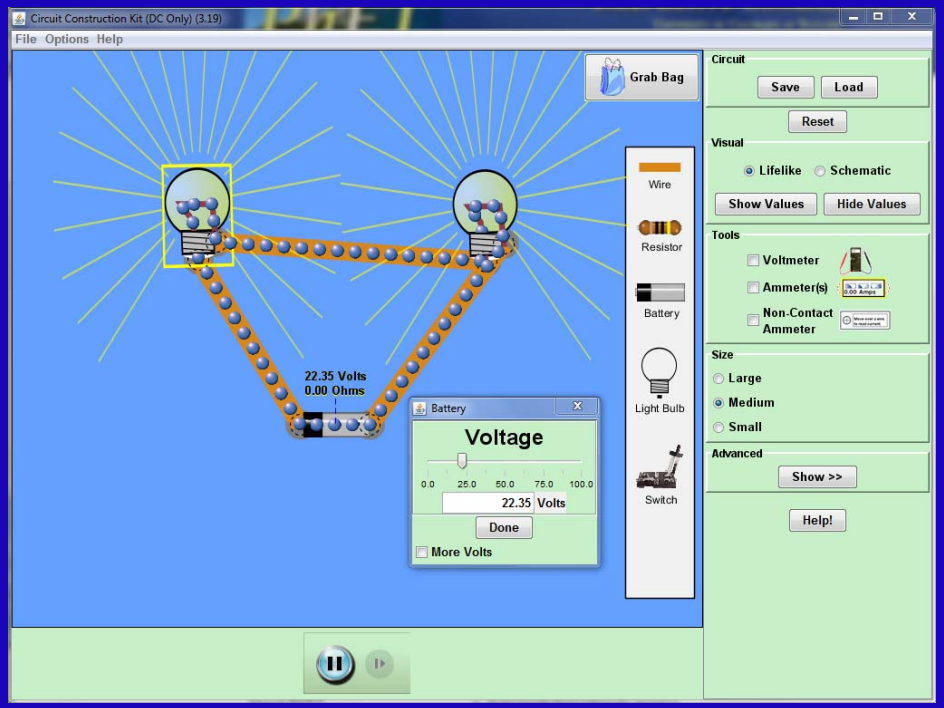
C) It does not change.

Why is PhET successful?

- Diverse design team
- User interviews
- Classroom testing
- Research-based

Design Philosophy

- Inviting, intuitive interface, usable without instructions
- Highly interactive: instant animated feedback as students explore
- Accurate, dynamic visual representations; show the invisible
- Allow actions that would be difficult or impossible in the real world
- Game-like environment
- Interface design that implicitly scaffolds inquiry



Research-Based Design supports inquiry-learning

Use accurate, dynamic visual representations

Show the invisible

Create a game-like environment

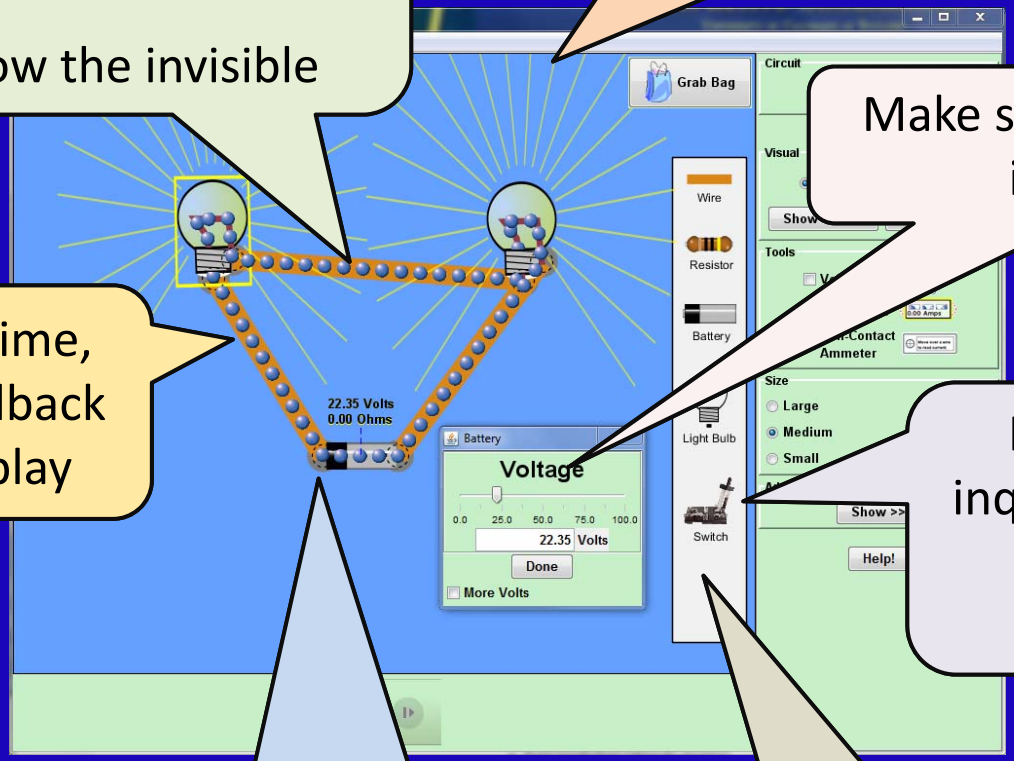
Make simulations highly interactive

Provide real-time, animated feedback as students play

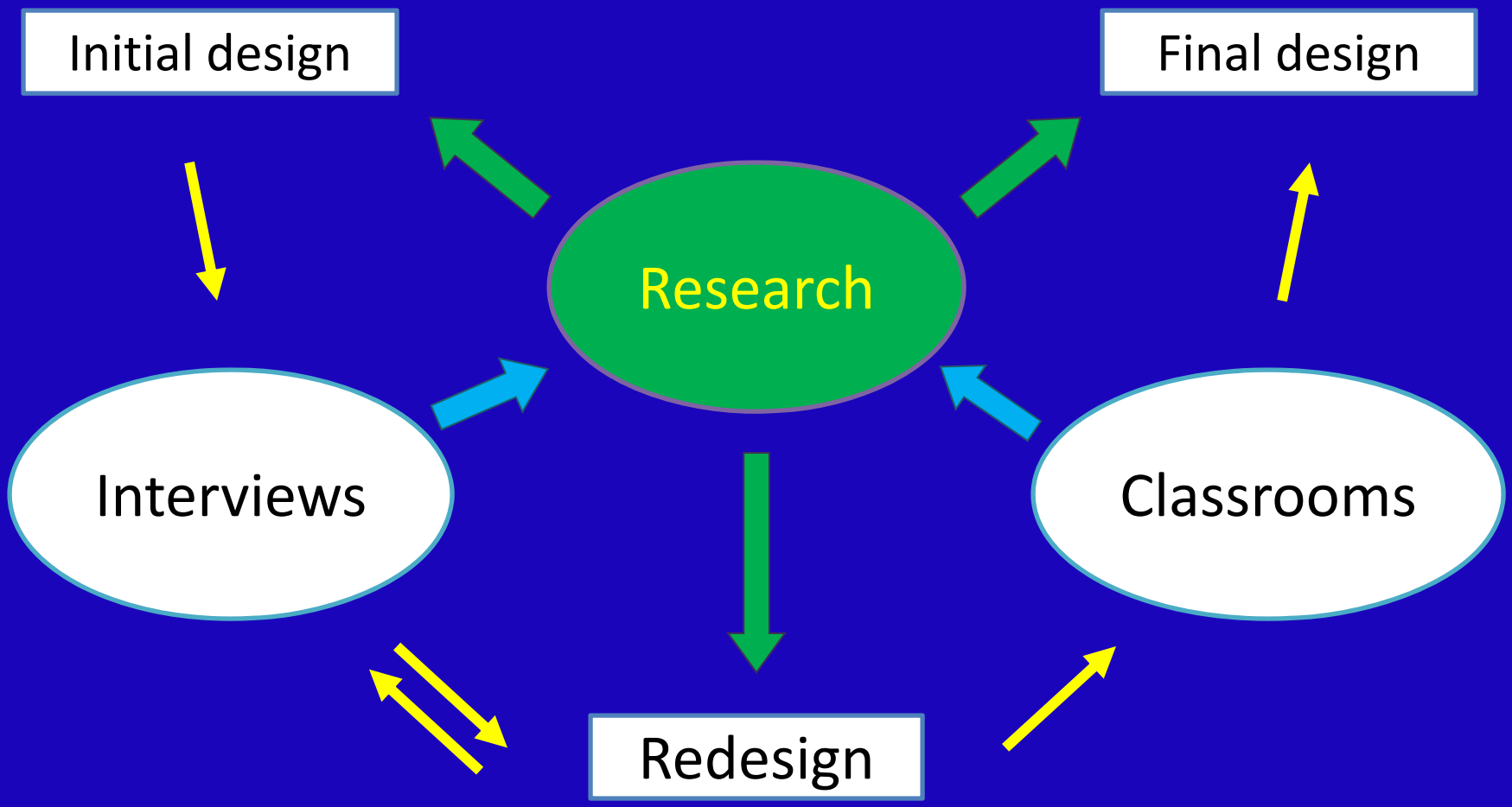
Implicitly scaffold inquiry through design of controls and representations

Allow actions that would be difficult or impossible in the real world

Provide an intuitive interface, usable without instructions

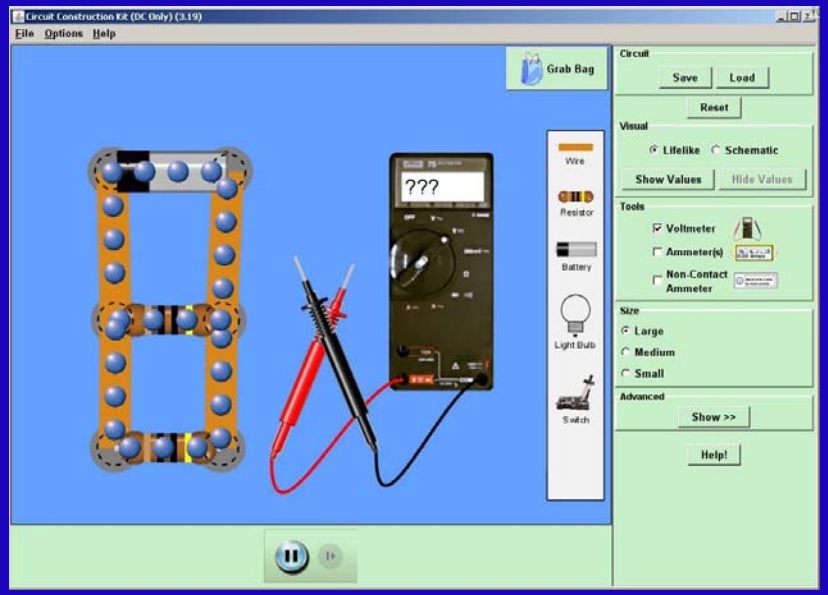


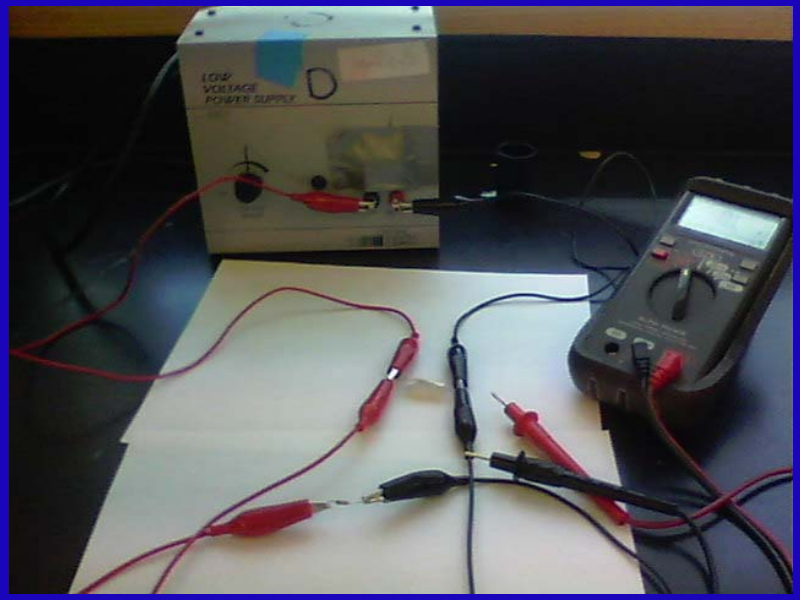
PhET Design Process
2 – 12 months, ≈$50K/sim



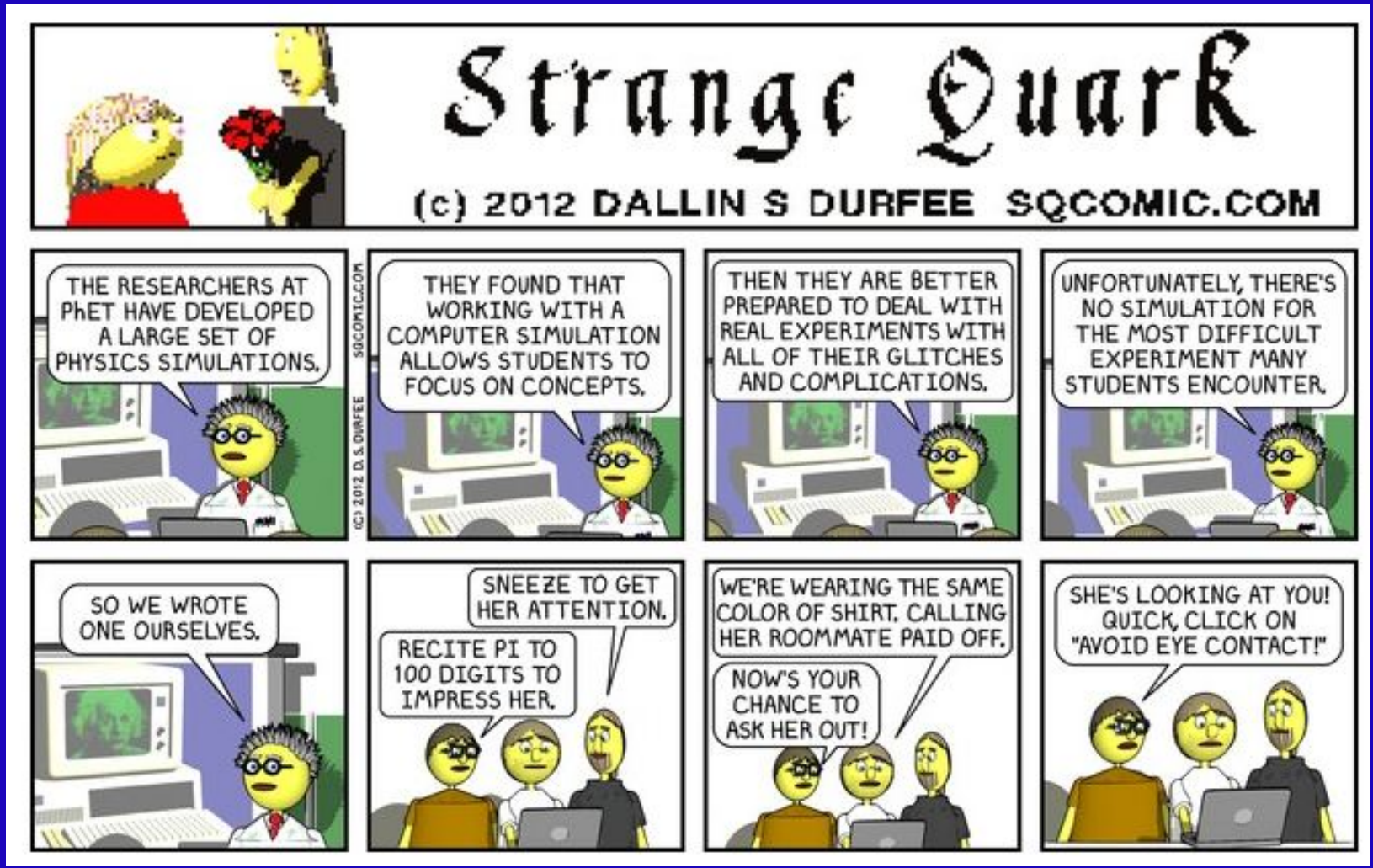
Compare these tools:

Your thoughts…





PhET in popular culture



Can PhET sims replace real equipment?

- They can, but we don't think they should.
- Meant to compliment, not replace with lab equipment.
- Sims lack real-world "dirt" effects, allow students to focus on physics concepts.

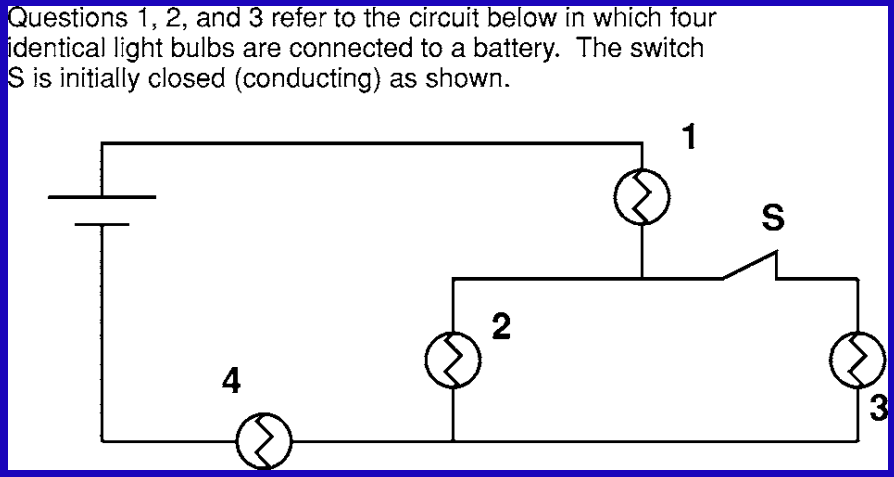
Circuit Construction Kit vs. real circuits

"When learning about the real world is better done virtually.. ", N.D. Finkelstein et al., **Phys. Rev. ST Phys. Educ. Res. 1**, 010103, 2005.

Students who only used virtual circuits, did equally well on building real circuits final.

Sims allow risk-free,

rapid inquiry cycle.



Do students learn if I just tell them to play with a sim?

- Seldom. Guided inquiry essential.
- Large data-base of classroom-tested activities available on the PhET site.

What makes a good sim activity?

- *Minimum* instruction.

  Detailed procedures *inhibit* student exploration.

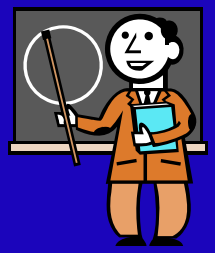
- Clear Learning Goals

  Give students the *goal*, not the procedure.

In-Class activity or Lab

Worse:

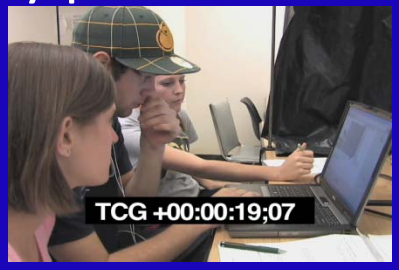
- Give directions on how to use the sim



- Result: Students are nervous, reluctant to try things, ask lots of questions about sim use, not learning goals.

Better:

- Provide activity and do not offer any pointers on the sim itself



- Result: Students explore uninhibitedly, quickly find/learn all the controls, become the "owner" of the sim.

Example Activity: Masses and Springs

- 5-10 minutes of play – No instructions.
- Challenge 1: Using data from the sim, make a graph that shows whether or not the springs obey Hooke's Law.
- Challenge 2: What is the mass of the red weight?
- Challenge 3: Determine the spring constant in two different ways: with your graph from (1) and with the stopwatch.

Cookbook directions (NOT effective):

- Watch me while I show you the controls.
- Measure the equilibrium extension of spring 1, for each of the 3 different known masses, and make a graph of stretch of the spring (on y-axis) vs. mass (on x-axis). From this, determine the spring constant k of the spring. Recall that $F_{spring} = -kx$, where x is the stretch of the spring. Don't forget that weight is mg, where $g = 9.8\ m/s^2$.

What would you like to see in PhET?

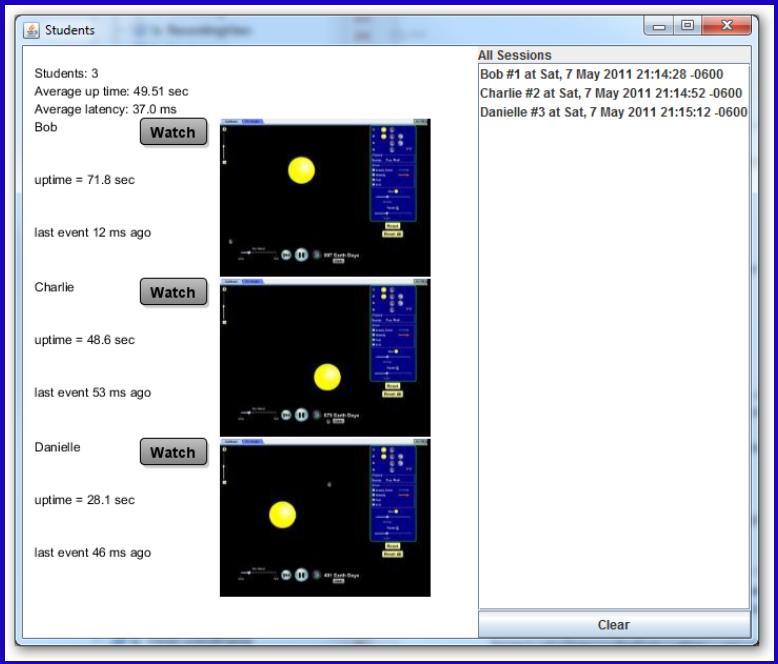
- Sim ideas? New features? ??

Door Prize! : You can see NEW sims in development, before they are published, at

http://www.colorado.edu/physics/phet/dev

The Future…

- More sims
- Compatibility with iPad
- Classroom sim sharing

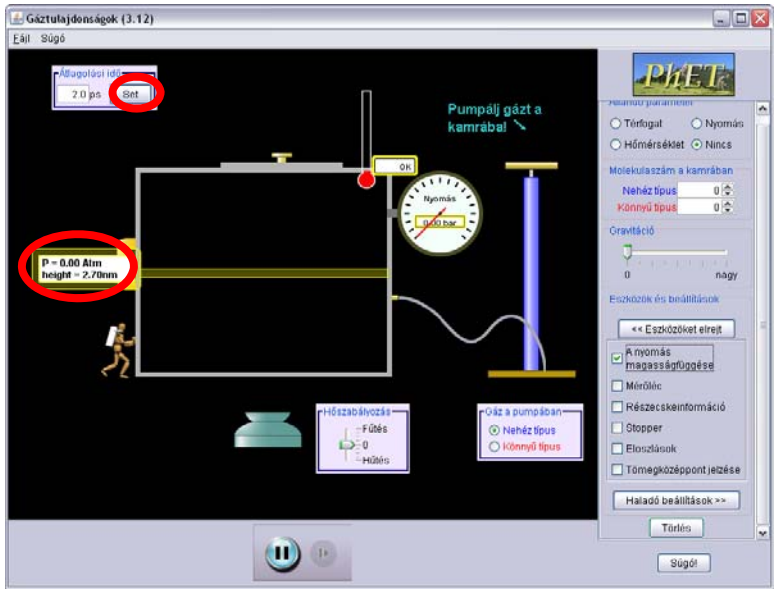


How can you contribute?

For Teachers > **Submit an Activity**

Report bugs

Send us your ideas for new sims!



Email: phethelp@colorado.edu

How can PhET be *free*?
Current budget > $1M / year

NSF

Hewlett Foundation

The O'Donnell Foundation

King Saud University

University of Colorado


Carl Wieman & Sarah Gilbert

How can PhET *stay* free?

- We're not sure.
- Major funding from grants not sustainable.
- Seeking corporate sponsors, large and small donors.
- Your advise or $$ gratefully accepted.

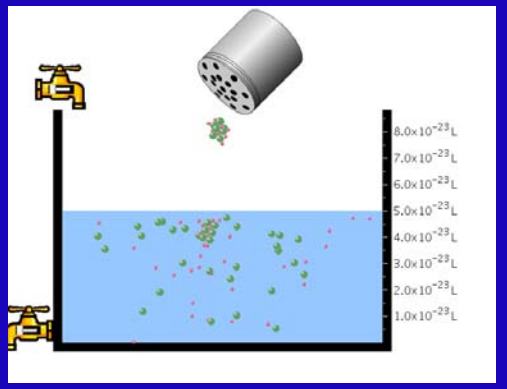
PhET Interactive Simulations

- Suite of >100 interactive simulations
- Physics , Chemistry , Math
  Expanding into biology, earth science
- Research-based and user-tested
- **Free!** Online or downloadable. (~130 MB)
- Easy to use and incorporate in class

http://phet.colorado.edu

Extra Slides Follow

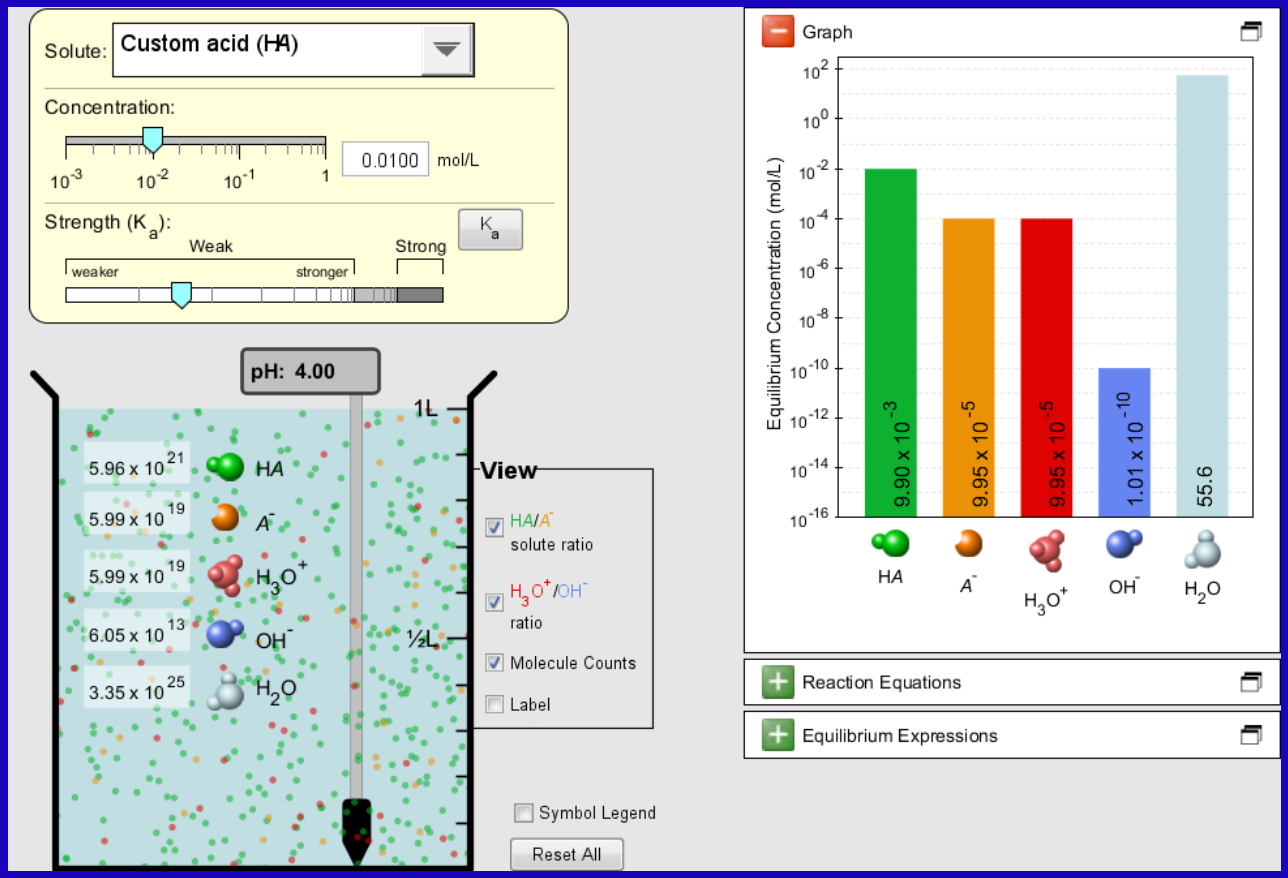
Designing Activities: What do students learn in each activity?



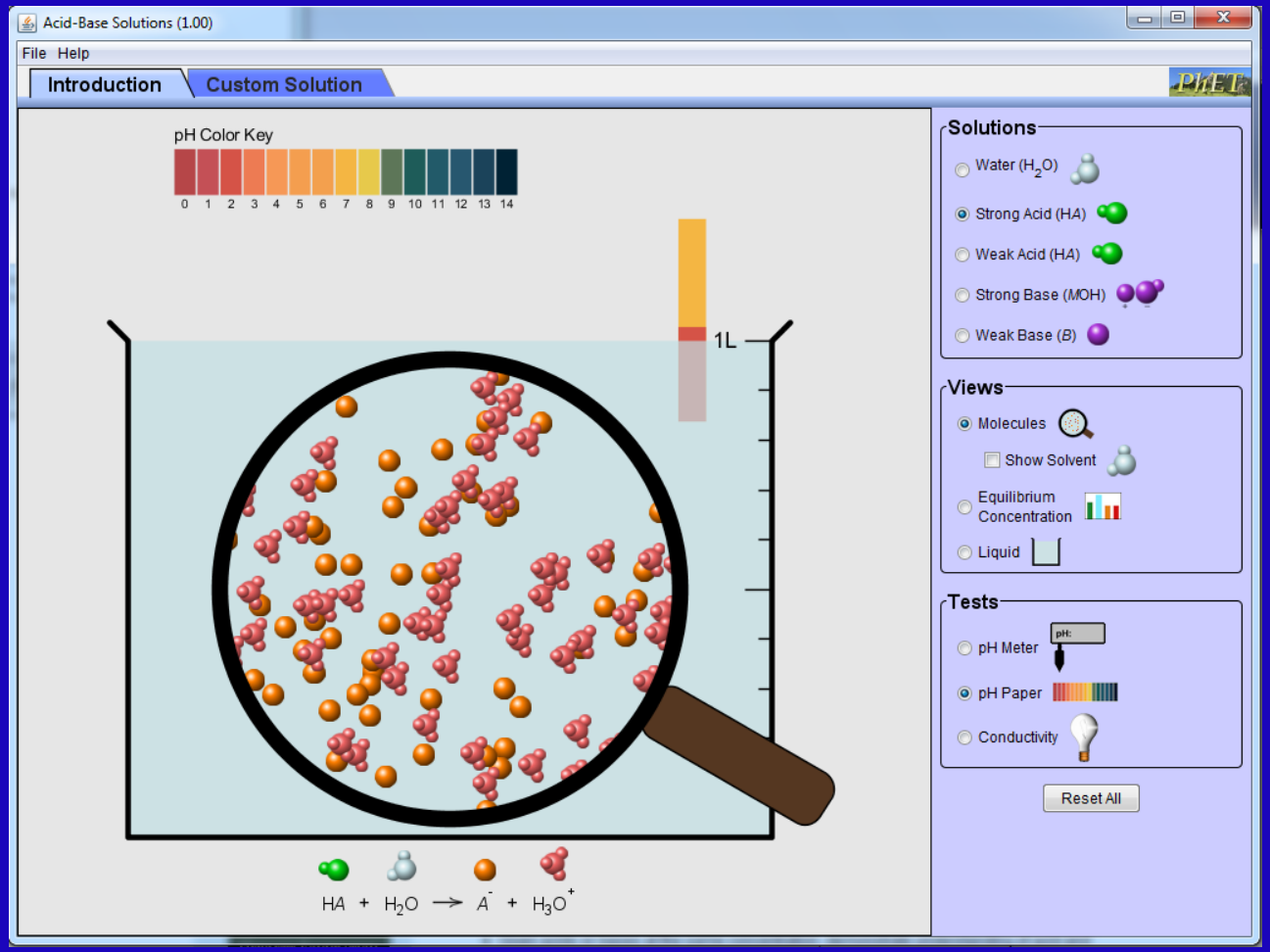
Add 100 silver bromide pairs to the water. How many silver and bromide ions dissolve in the water? Repeat this for all salts.

Investigate different salts. What features do salts have in common, and how do salts differ from each other?

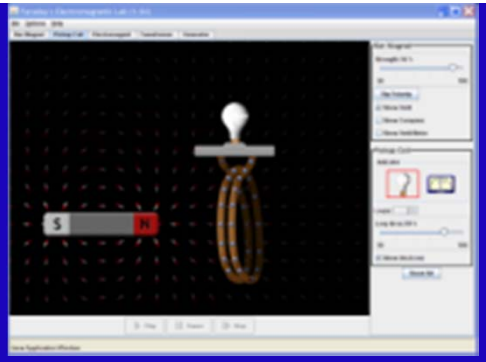
Old Acid-Base Solutions



New Acid-Base Solutions



Why is this sim better?



Interview Study: Type of Guidance

Compared two types of guidance
Examined Student Behavior

Open Conceptual Questions +

Guided Activity

In the "Bar Magnet" tab, identify all controls, … What does the "Strength" slider do?

Open Conceptual Questions

↓

Free exploration of sim

Results

Guided Activity

Student Mode:

Students answer question and wait for the next.

"OK, continue?"

"Is that sufficient for step 2?

Often don't tie pieces together.

Open Conceptual Questions

Scientist-like Exploration:

Explore via their own questioning

"Oh, I wasn't expecting that"

"I was looking around to see if it was an effect of having more wires."

What did students explore?

12 features <u>not</u> mentioned in the Cookbook activity: