

Including Evidence in Lecture-Format Courses: Comparing Videos and Hands-On Experiments and Simulations

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Learning Physics (LEP)

LEP is a new guided inquiry, conceptual physics curriculum suitable for large classes. LEP is one of a family of related curricula: *Learning Physical Science* (LEPS) [1, 2], *Physical Science & Everyday Thinking* (PSET), & *Physics & Everyday Thinking* (PET) [3]. Conceptual themes include conservation of energy and Newton's laws, light, magnetism, and electricity.

In LEP, students:

Watch videos of experiments/sims
Do hands-on work in small groups
Answer open-ended prompts to make predictions, make sense of observations, and interpret representations

Engage in small group discussions
Support claims with evidence & reasoning
Develop and use models
Write and evaluate explanations using a structured, web-based system

Pedagogical modes in LEP

During ~half the course, groups do hands-on experiments and simulations. Remaining class time is spent on instructor-guided lessons featuring videos of demonstrations, peer discussion, and "clicker" questions, similar to LEPS [1, 2]



Videos

Used during exploration of interactions, energy, & forces.

CQ 1-1: Which point on the graph is closest to where you think the force of the stick stopped acting on the puck?

A. Point A
B. Point B
C. Point C
D. Not until the puck stops



Hands-on experiments and simulations

Used during exploration of light, electric circuits, magnetic effects; and during model building for static electricity and magnetism.

Lesson 2: Reflection of Light and Plane Mirrors

Part 2: Reflection of light from a flat, shiny surface (mirror)

Suppose you had a small, flat mirror and covered up all of it except for a narrow strip. Imagine that you put a point source (tip of flashlight) on the table as shown below in the top view diagram.

CQ 2.8: From which one of the positions do you think you would be able to see the image of the light source in the narrow strip of mirror?

Try it! Tape an index card to the mirror, leaving only a thin strip of mirror exposed (about a 1/4 inch or less) at the right end. Support the mirror and card with a small piece of clay. Place Maglite™ as shown in the picture below. Bend down so your eye is at desktop level and look along the directions suggested in the CQ and record from where you can see the image of the source in the mirror.



Comparing videos and hands-on: Features

Videos Are designed to reduce distractions and ensure unambiguous results
Provide better visibility for the entire class
Allow instructor to pause, slow down, or replay the action
Eliminate setup time and "failed" experiments (unintended observations)

Hands-on Allow students to directly experience of the phenomena
Allow for exploration, testing ideas, and creativity
Require materials and time for logistics
Require more effective groups and instructor-student interactions

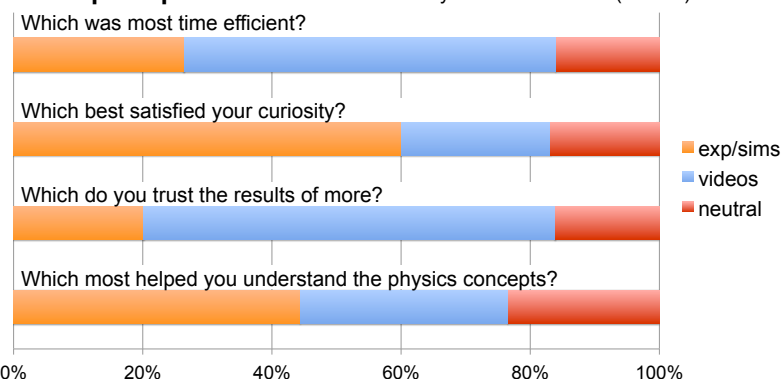
Classroom experience with hands-on activities

Students regularly engage in discussing the meaning of an observation. During an experiment on possible magnetic interactions:



S2: Sometimes it's attracting, sometimes it's...
S1: It's stuck on that side.
S3: Oh, it is attracting. **S2:** Try the other way.
S4: I think it's just moving because of the water. **S3:** Yeah. **S2:** Yeah.
S2: It just takes time for it to sort of like change direction
S3: Ok. So... **S2:** Wait, you don't think it's affected?
S3: No. **S4:** [Shakes head no]
S2: Really? Let me see. Cause I feel it just takes a while but it does attract, doesn't it?
S4: I think the way it's moving, it's just cause the water.
S3: Yeah. **S2:** So no noticeable effect.

Student perception End of semester survey in 2 LEP classes (N=124)



Which goals to pursue?

Based on classroom observations and student perceptions...

Videos are more time efficient at providing evidence for developing physics concepts;
Hands-on activities allow students to engage in science practices, and develop greater judgment and interpretive skills.

The choice of how to spend class time represents a choice between goals. LEP balances this choice with a mix of activities.

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References

1. F. Goldberg, et al. *Phys. Rev. ST Phys. Educ. Res.* 8, 010121, 2012.
2. F. Goldberg, et al. *Learning Physical Science*. It's About Time, Mount Kisco, New York, 10549, 2012.
3. F. Goldberg, et al. *Physics and Everyday Thinking*, It's About Time: Armonk, NY, 2005.