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

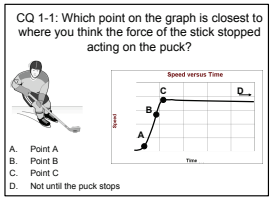
Engage in small group discussions
Support claims with evidence & reasoning
Develop and use models
Write and evaluate explanations using a structured, web-based system

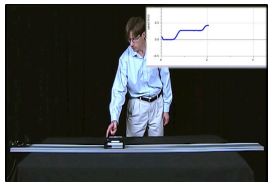
Pedagogical modes in LEP

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

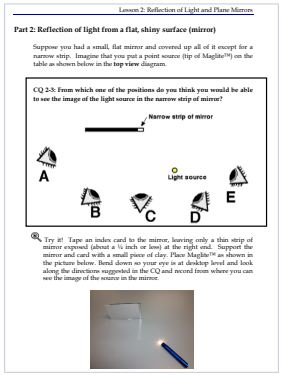
Used during exploration of interactions, energy, & forces.





Hands-on experiments and simulations

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

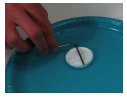


Comparing videos and hands-on: Features

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

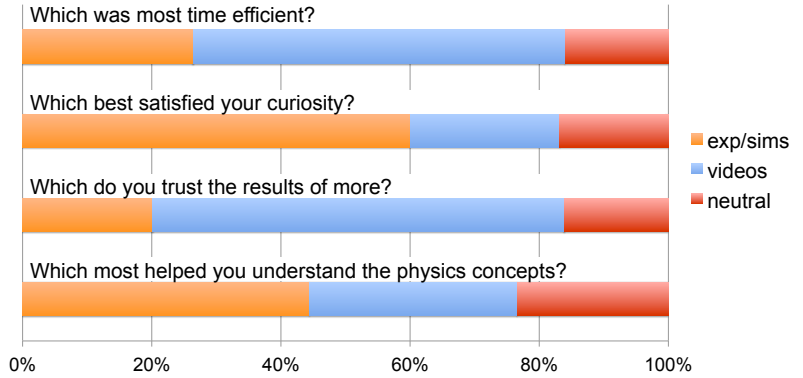
Classroom experience with hands-on activities

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.

Acknowledgements

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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.