Distance-Learning Labs for Introductory College Physics

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Outline

- Goals of labs
- Measuring lab learning
- Research by others
- Various approaches to online labs
- My labs and my research
- Unsolicited observations for online physics
Why Do Labs?
American Association of Physics Teachers Lab Learning Outcomes

- **Constructing knowledge** – collect, analyze, and interpret real data from personal observations of the physical world to develop a physical worldview.
- **Modeling** – develop abstract representations of real systems studied in the laboratory, understand their limitations and uncertainties, and make predictions using models.
- **Designing experiments** – develop, engineer, and troubleshoot experiments to test models and hypotheses within specific constraints such as cost, time, safety, and available equipment.
- **Developing technical and practical laboratory skills** – become proficient using common test equipment in a range of standard laboratory measurements while being cognizant of device limitations.
- **Analyzing and visualizing data** – analyze and display data using statistical methods and critically interpret the validity and limitations of these data and their uncertainties.
- **Communicating physics** – present results and ideas with reasoned arguments supported by experimental evidence and utilizing appropriate and authentic written and verbal forms.
How Do You Measure Lab Learning?

A) Conceptual physics (FCI, FMCE, etc.)
B) Exams or grades
C) Attitudes (E-CLASS)
D) Lab specific skills (PLIC)
E) Other
F) Don’t do it
Force and Motion Conceptual Evaluation (FMCE)

Friction and drag forces are negligible. Which force would keep the sled moving toward the right at a steady (constant) velocity?

A. The force is toward the right and is increasing in strength (magnitude).
B. The force is toward the right and is of constant strength (magnitude).
C. The force is toward the right and is decreasing in strength (magnitude).
D. No applied force is needed.
E. The force is toward the left and is decreasing in strength (magnitude).
F. The force is toward the left and is of constant strength (magnitude).
G. The force is toward the left and is increasing in strength (magnitude).
Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS)

1. When doing an experiment, I try to understand how the experimental setup works.

Strongly Disagree 1 2 3 4 5 Strongly Agree

What do YOU think when doing experiments for class?

What would experimental physicists say about their research?
Physics Lab Inventory of Critical Thinking (PLIC)

How well do you think Group 1’s method tested the model for the period of the spring bounces? Use a scale where 1 means the method was very bad and 5 means the method was very good.

1 (very bad) 2 3 4 5 (very good)

What features of their method are most important for evaluating the method? Please select no more than 3 options.

- □ The number of bounces of the spring per trial
- □ The number of repeated trials for each mass
- □ The number of masses tested
- □ How they tested other possible variables
- □ How they accounted for human error
- □ The equipment they used (i.e. stopwatches)
- □ How similar the two spring constant values (k) are
- □ The size of the uncertainty (or variability between data)
- □ How clear, organized, or detailed their lab notes are
- □ Their analysis and calculations
- □ The way they reported their raw data
- □ Other (Please describe)
Research on Campus-Based Labs

- Traditional labs = no improvement on exams (Holmes, Wieman)
- Traditional labs = no increase in expert-like attitudes (Wilcox, Lewandowskis)
- RealTime Physics = conceptual gains (Sokoloff, Laws, Thornton)
How Do You Do Online Labs?

A) Commercial kit
B) Multi-purpose sensors (IOLab, PocketLab)
C) Household items (phones, etc.)
D) Video analysis
E) Simulations or other non-traditional activity
F) Arduinos
G) Other
H) Haven’t done it yet
Commercial Lab Kits
Multi-Purpose Sensors
Phones and Household Items
Video Analysis (Tracker)
Lab Alternatives

- Simulations (PhET)
- Analysis of data or videos generated by others
Custom Lab Kits (My Initial Approach)
Supplement with Objects at Home

Anvil
Multivariable Regression of Grades for Campus-Based and Online Introductory Physics at Chemeketa

Which variable do you think is the best predictor of success (or failure), as determined by a large coefficient and a small P value?

A) GPA  
B) Trigonometry grade  
C) Being a Chemeketa Community College student  
D) Taking the class online  
E) Gender  
F) What are multivariable regressions and p-values?
Multivariable Regression of Grades for Campus-Based and Online Introductory Physics at Chemeketa

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>P value</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>GPA</td>
<td>1.2</td>
<td>1.8E-25</td>
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<tr>
<td>Trigonometry Grade</td>
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<td>Female</td>
<td>0.0054</td>
<td>0.97</td>
<td>No effect</td>
</tr>
</tbody>
</table>
RealTime Physics and IOLab

David Sokoloff
University of Oregon
Erik Bodegom
Portland State University

DUE 1505086
RealTime Physics

• Active and discovery-based lab learning
• Real time graphical data collection
• Research validated

But…
• Not designed for distance education
The IOLab includes...

• Wheel sensor for position, velocity, and acceleration
• Force sensor
• Light intensity sensor
• Atmospheric pressure sensor
• Microphone
• Temperature sensor
• 3D Accelerometer
• 3D Magnetometer
• 3D Gyroscope
• More
Activity 2-4: Reversing Direction

Prediction 2-7: Select the graph below that correctly describes velocity vs. time for this motion, slowing down as the IOLab moves up the ramp in the positive direction, coming to rest, reversing direction and speeding up as the it moves down the ramp in the negative direction.

A B C D E
Analysis and Reflection

Activity 2-4: Reversing Direction

Question 2-30: According to your acceleration graph, is the acceleration at the instant the IOLab reaches its turning point +, 0 or -?

-  +
-  -
-  0

Question 2-31A: Is the acceleration significantly different from that during the rest of the motion?

-  Yes
-  No

Question 2-31B: Does this agree with your prediction?

-  Yes
-  No
E-CLASS Prediction

A) Significant improvement
B) Slight improvement
C) No effect
D) Slight harm
E) Significant harm
E-CLASS Results

A) Significant improvement
B) Slight improvement
C) No effect
D) Slight harm
E) Significant harm
FMCE Prediction

A) Significant improvement
B) Slight improvement
C) No effect
D) Slight damage
E) Significant damage
Conclusions for Online Labs

- Substantive labs can be done online for a reasonable price
- Labs are not likely to lead to measurable learning unless properly designed
- There is an increasing emphasis on student-directed labs (ISLE) and measuring lab-specific skills (PLIC)
Warnings for Online Physics

- High dropout rates
- Tech support is a huge hassle (Chromebooks, Macs, etc)
- Cheating (Chegg, Course Hero, etc.) is a serious problem
Thanks

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- PICUP
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https://www.youtube.com/channel/UCawFPBfOJLYjv_8Gw4HJ6Bw

Link to this presentation in Google Slides (this will include notes and links not included in the .pdf version):
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