Colorado Learning About Science Survey for Experimental Physics

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How do our labs impact students?

“How traditional introductory laboratory courses generally do not capture the creativity of STEM disciplines. They often involve repeating classical experiments to reproduce known results, rather than engaging students in experiments with the possibility of true discovery. Students may infer from such courses that STEM fields involve repeating what is known to have worked in the past rather than exploring the unknown.”

- PCAST, Engage To Excel (2012)
New Lab Environments

Real Time Physics

Single Photon Experiments

Guide to the Expression of Uncertainty in Measurement

Emphasis: Error Analysis

I.S.L.E.

Emphasis: Scientific Abilities

Emphasis: Conceptual Learning
2004: CLASS  
(Colorado Learning Attitudes about Science Survey)

2012: E-CLASS

1) Common evaluation tool that can be applied to the existing variety of lab experiences

2) Aspect of the lab that can be evaluated easily.

3) Aligns with a common learning goal.
Transformation Model

Consensus learning goals

What should students learn?

Assessments

What are students learning?

Research-based curriculum development

Department
Faculty
PER Postdocs

What approaches improve student learning?
Development of Learning Goals

21 faculty

- Modeling the physical system
- Modeling the measurement system
- Statistical analysis for comparison

- Designing apparatus and experiments
- Troubleshooting

- Modeling

- Design

Communication

- Argumentation
- Authentic forms in physics

Technical lab skills

- LabVIEW
- Test and measurement equipment

LEARNING GOALS
1) A new survey focused on experimental physics

2) Validated for all levels of university students

3) A common evaluation tool than can be applied to a variety of lab experiences across the country.
E-CLASS Dimensions

Affect
Scientific Argumentation
Confidence
Experimental design
Math-Physics-Data connection
Modeling the measurement system
Physics community
Purpose of labs
Statistical uncertainty
Systematic error
Troubleshooting
Validation - Students

19 interviews with all levels of college students. Students took the survey and then explain how they answered it.

When I am doing an experiment, I try to decide what would be a reasonable value for the result.

| Strongly Disagree | 1 | 2 | 3 | 4 | 5 | Strongly Agree |

Students: “What *do* I think vs. what *should* I think?”

Add: “What would a physicist say?”

Students: about lab class or their research lab?

Modify: “What would a physicist say about their research?”

Students: what about theorists?

Final: “What would experimental physicists say about their research?”
E-CLASS Design

Paired Questions

1. Students' personal attitudes and beliefs
2. Students' view of experts

Core concept:
(e.g., Communicating scientific results to peers is a key part of scientific research)

3. Does this practice help to earn a good grade?
4. Frequency of engaging in the practice

Actionable evidence for instructor
Example: modeling the measurement system

<table>
<thead>
<tr>
<th>Pre- and Post-semester</th>
<th>Personal / Expert Pairs</th>
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<tbody>
<tr>
<td>I don't need to understand how the measurement tools and sensors work in order to carry out an experiment.</td>
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Strongly Disagree 1  2  3  4  5  Strongly Agree

What do YOU think?  ○  ○  ○  ○  ○
What would an experimental physicist say about their research?  ○  ○  ○  ○  ○
Six faculty with active experimental research labs took the 30 statement survey to establish the expert view.

- 22 statements: 100% agreement

- 5 statements: 5 matching agreement + 1 neutral

- 2 statements: 4 matching agreement
  “Working in a group is an important part of doing physics experiments.”
  “When I encounter difficulties in the lab, my first step is to ask an expert, like the instructor.”

- 1 statement did not have consensus. (2 Agree, 3 Neutral, 1 Disagree)
  “Nearly all students are capable of doing a physics experiment if they work at it.”
Final Survey

23 core concepts/practices (evaluated in all 4 quadrants)

7 additional ideas related to affect, confidence, purpose of labs (assessed only using the personal/expert pairs)

Pre-test: 60 items (5-7 minutes)
Post-test 106 items (10-15 minutes)
Statement: “Doing error analysis (such as calculating the propagated error) usually helps me understand my results better.”

1) Understand physicists see it as important, but not helpful for students.
2) Is it not helpful because they are not evaluated on this aspect?
1) Important for earning a good grade but not helpful for understanding their data.
2) Maybe it would have been helpful if they actually engaged in the process frequently.
1) They engaged in the practice frequently and consistent with their perception of the grading importance.
Offer to the Community

We would like to offer the survey to as many students as possible in diverse environments and courses.

We will…

1) provide the online administration of the survey.
2) deal with IRB approval for the survey at CU- Boulder.
3) give you a report with analysis of the anonymized students’ responses.
4) provide a list of students that completed the survey.

All you have to do is…

1) contact us as soon as possible before the semester starts.
2) give a very small amount of credit or extra credit to incentivise participation.
3) fill out a short factual survey about your university, department, and course.

spot.colorado.edu/~bezw0974/E-CLASS_Survey.html
Conclusions

1) E-CLASS survey has the promise to become an broadly useful assessment tool to measure one class of learning outcomes.

2) We urge the community of physics lab instructors to implement this easy and hopefully informative assessment.

3) There are many other learning outcomes that must be measured and we are actively working on those assessment tools. (Conceptual Learning gain with Single-photon labs soon!)

Manuscript submitted to PERC: “Development and Validation of the Colorado Learning Attitudes about Science Survey for Experimental Physics”

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