Developing student attitudes in the first-year physics lab at UBC

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Labs originally in Physics 107 (enriched physics) & Science One

Now also in new course Physics 119 (~400 students, science majors)

Lab Activities Focus on Quantitative Comparison and Iteration

Students make comparisons between their own measured quantities — never just confirming known expert results

- e.g., authentic comparison: measure period of a pendulum two different ways
- rather than classical lab comparison: measure mass of electron and compare with standard result

- **Experimental cycle (Scaffolded at beginning with instructions and marks)**
  - ➢ **Plan measurements**
  - ➢ **Do measurements**
  - ➢ **Make a comparison**
  - ➢ **Reflect on comparison**
  - ➢ **Plan an improvement**

Iterate

Labs designed by Natasha Holmes, Doug Bonn, Carl Wieman

Previous Results (from Phase I of Lab Transformation)

N.G. Holmes, C.E. Wieman, D.A. Bonn (2015), *PNAS*, 112(36), 1199:

- Students carry their practices of reflecting on results and making improvements over into their 2nd-year lab course!

However, students did not show significant overall shift in *attitudes* about experimental science (measured by ECLASS, see next page)

— They were learning, but didn't fully recognize that themselves

What do students think about experimental science?

E-CLASS: Experimental Colorado Learning Attitudes about Science Survey (e.g., Zwickl et al. 2013)

Rate each statement from strongly disagree to strong agree.
Example statements:

- If I wanted to, I think I could be good at doing research.
- When doing a physics experiment, I don't think much about sources of systematic error.
- The primary purpose of doing a physics experiment is to confirm previously known results.
- Working in a group is an important part of doing physics experiments.
- Physics experiments contribute to the growth of scientific knowledge.

UBC Physics lab students took ECLASS at beginning and end of semester.
Past result: no change in attitude.
Current results ongoing: Students for 2015-2016 took pre-semester ECLASS in Sept/Jan and are taking post-semester ECLASS this week.

Phase II of Lab Transformation: Focus on students' attitudes

Idea:

We could improve students' attitudes by having them reflect more on their learning:

- Reflect on how what they're learning is broadly applicable (other classes, everyday life)

- Reflect on themselves as developing scientists

We designed reflection questions for Ph119 online prelab assignments, scattered through the semester.

Sample Reflection Prompt

What have you learned in this lab that is useful for you as a scientist?

Student response:

"The activity [about histograms] really boosted our creativity and really made us thinking what is the most appropriate and accurate way to find the answer. It is similar like having a scientific question, then creating / designing an experiment to solve the question. This skill is very important as a scientist."

Sample Reflection Prompt

Think of a measurement you've made previously, outside this class. Describe the measurement; think about major sources of uncertainties, and why and how you could improve it.

Student response:

"I have measured my weight every day for a month

Once source of error was that I was not being consistent in the time of the day that I was weighing myself and as a result some of the daily fluctuations that I saw was as a result of taking measurements differently every day. In other words, the changes did not really reflect true changes in my weight. The changes were due to measurement error because I was not being consistent with my measurements.

I should weigh myself every day at the same time during the day and should wear the same clothing every time I weigh myself. It is also important that I use the same scale every day."

Sample Reflection Prompt

Gravitational Waves! Read abstract to the scientific paper; Discuss two pieces you noticed that relate to aspects we have been learning in class.

Student response:

"The abstract describes several numeric uncertainties in the findings. Uncertainties have been an important recurring concept in class, especially their analysis, as this gives us a way to determine how accurate and trustworthy the data is. Careful analysis of uncertainties can reveal issues in the experiment, opportunities for improving it, or support its findings. Here, uncertainties are used to confirm that a groundbreaking discovery did, in fact, happen (and that the results are not something we "think" we saw but that were actually due to error)."

Sample Reflection Prompt

As you wrap up this course and look ahead, what are two things you have learned in Physics 119 that you plan to use in your future science courses and career?
Why are these important, and how will you use them?

Student response:

"-I've learned that you can't always blindly trust the fomulas you're given. In physics 119 we used concepts that I'd covered in phyics 101, except that we figured out the relationship between the variables ourselves and proved that the formulas are only useful in certain circumstances (for example, the small angle approximation). This process of us using our data to "prove" formulas that normally we're just given in class was really eye opening for me. It gave me a better understanding of and appreciation for experimental physics. I plan to keep this in mind when we learn new concepts in the classroom, realizing now that all the formulas we know came from somewhere. They were all hypothesized, tried and tested in a lab like ours somewhere.

-I've learned again and again that uncertainties matter. In the classroom uncertainties are normally ignored, but in 119 we learned so much about what your uncertainties can tell you about your data. I now have a much better appreciation for the fact that physics isn't just about plugging in numbers and getting an answer. It's about trying things, learning and definitely analyzing your results to come up with a conclusion."

Ongoing work

- **Students in Ph119 and Ph107 / Science One took the ECLASS survey at the beginning of the semester and are currently taking the post-semester ECLASS survey.** ***Will we find a shift in their attitudes?***

- **If there is a shift in student attitudes, are the reflection questions responsible? (Systematic study of student reflection responses)**

- **Is the ECLASS the best tool to study student attitudes? (e.g., does not directly address student's self-image as a scientist, and their belief in science as a description of the real world) Is there a better tool to use?**