The Impact of Targeted Learning Goals on Student Attitudes about Experimental Physics

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Aim: To compare the impact of two introductory physics labs on students' perceptions and attitudes about experimental physics, as measured by the Colorado Learning and Attitudes about Science Survey for Experimental Physics (E-CLASS) [1].

Traditional lab (n=453):
- Targets the development of a large number of skills
- Synchronizes with and supports the physics topics in lecture
- No explicit goals to develop expert-like scientific reasoning
- Non-majors calculus-based physics curriculum

Scaffolded Scientific Reasoning lab (SSR, n=127):
- Narrow set of learning outcomes about data handling, statistics, measurement, and uncertainties [2]
- Activities scaffolded to develop students' scientific reasoning behaviours and epistemologies about the nature of scientific measurement and uncertainty
- Enriched, calculus-based physics curriculum, 25% physics majors

E-CLASS

The E-CLASS poses questions about 30 attitude and epistemology concepts in three ways [1]:

Students' personal attitudes and beliefs
- What do you think?

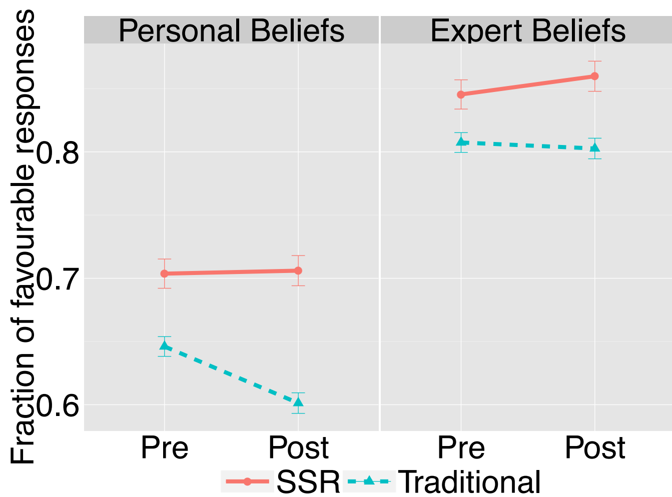
Students' views of experts
- What would an experimental physicist say about their research?

Students' views of the importance
- How important for earning a good grade in this class was…?

All 30 concepts were posed as personal and expert beliefs questions both on pre- and post-surveys, while 23 concepts were also posed for level of importance in the course on post-survey only.

REFERENCES
1. B.M. Zwickl, N.D. Finkelstein, and H.J. Lewandowski, in *2012 PERC Proceedings*, AIP Conf. Proc. 1513, 442-445
2. J. Day, and D.A. Bonn, Phys. *Phys. Rev. ST Phys. Educ. Res*, **7**(1), 010114 (2011)
3. E.F. Redish, J.M. Saul, and R.N. Steinberg, *Am. J. Phys*. **66**(3), 212–224 (1998)
4. W.K. Adams, K.K. Perkins, N.S. Podolefsky, M. Dubson, N.D. Finkelstein, and C.E. Wieman, *Phys. Rev. ST Phys. Educ. Res*. **2**(1), 010101 (2006)
5. E. Brewe, L. Kramer, and G. O'Brien. *Phys. Rev. ST Phys. Educ. Res*, **5**(1), 013102 (2009)
6. V.K. Otero, and K.E. Gray, *Phys. Rev. ST Phys. Educ. Res*, **4**(2), 020104 (2008)
7. A. Elby, *Am. J. Phys.* **69**(S1), S54–S64 (2001)

Survey Outcomes

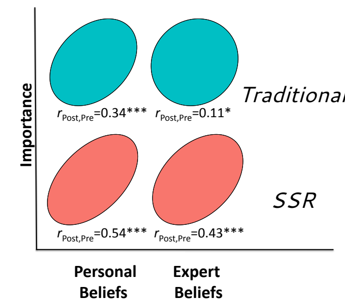


OVERALL SCORES

In the traditional lab, students' personal beliefs deteriorated during the course, while expert beliefs did not shift. This is in line with other results on attitudes in traditional courses [3,4] and further suggests that the traditional lab did not engage students in the scientific process [5,6]. Students in the SSR lab did not change their beliefs across the term. There were significant positive shifts on key concepts (such as uncertainties and systematic errors) and negative shifts on items deliberately not targeted (such as experimental design). The lack of overall positive shifts suggests that explicit focus on epistemologies is required [7].

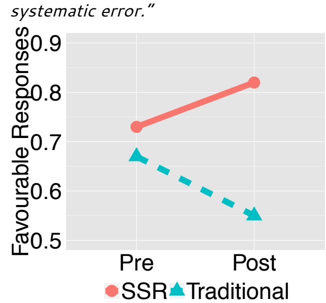
COURSE ASSESSMENT

Students in the SSR lab overall rated the E-CLASS items as more important for earning a good grade in the course than the students in the traditional lab. There were also significant correlations between the importance for earning a good grade in the course and students' personal and expert beliefs (stronger for the SSR lab).
$^*p<.05$, $^{**}p<.01$, $^{***}p<.001$



SAMPLE ITEM: SYSTEMATIC ERRORS

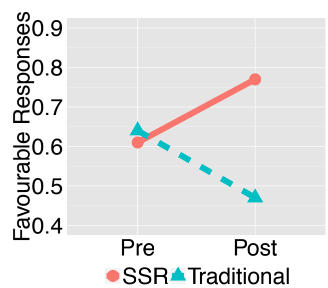
"When doing a physics experiment, I don't think much about sources of systematic error."



Students had to confront whether their measurements disagreed with a given theory due to systematic errors in their measurements or systematic deviations in the theory.

SAMPLE ITEM: UNCERTAINTIES

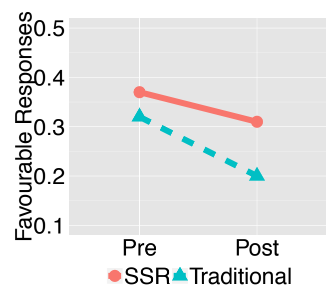
"Calculating uncertainties usually helps me understand my results better"



Reflect, iterate, improve cycles moved uncertainties from abstract calculations required by the instructor to important tools that were useful for understanding their data.

SAMPLE ITEM: EXPERIMENTAL DESIGN

"When doing an experiment I usually think up my own questions to investigate"



The SSR lab deliberately did not involve experimental design and students do not do experiments that come from their own research questions.

KEY RESULTS

- Targeting scientific reasoning produces neutral shifts, improving on negative shifts of traditional labs
- Correlations between assessment and attitudes reinforce the importance of aligning assessment with course learning goals
- Explicitly addressing students' epistemologies may be required for positive shifts