Effectiveness of flipped classroom techniques in an advanced laboratory physics course

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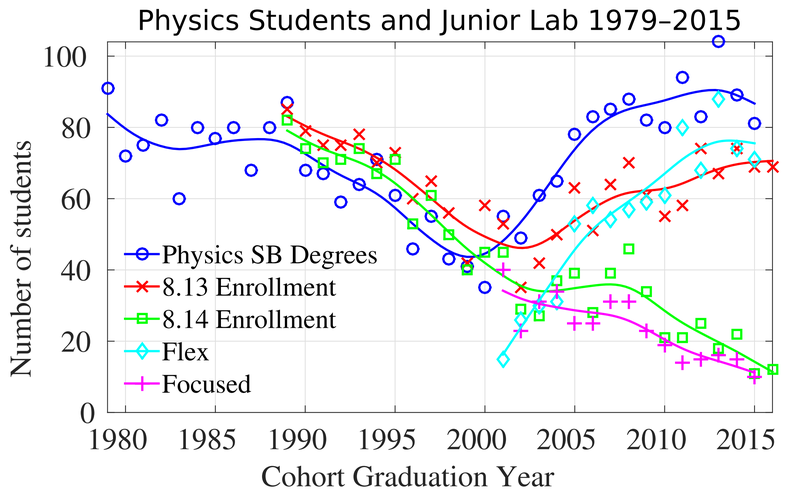
Project Overview

- Departmental project since 2010 to:
  - **better achieve learning goals** and **promote expert attitudes** in experimental physics
  - **increase enrollment** in advanced lab ("**Junior Lab**")



Goal: increase enrollment in 8.14 by improving 8.13. 8.14 is optional in the "flexible" major track and required in the "focused" track. These data show that the 2012/2013 changes to 8.13 have had negligible effect on 8.14 enrollments, at best stabilizing a previously falling trend.

- Why don't students continue in advanced lab?
  1. Second semester is not required?
  2. First semester is **too time consuming**?
  3. First semester is **too demoralizing**?
  4. Something else?
- ⇒ **Improve student learning experience** in the first semester of advanced lab.

Two stage implementation:

- **Fall 2012**: Expand introductory curriculum, reduce number of experiments
- **Fall 2013**: Flip the exercises and lectures, using edX, . . . only for parts of the course where that makes sense!

A **natural experiment** (not fully controlled) on effectiveness of **flipped classroom** techniques in a **lab environment**.

See also

For more detail: Robinson, S.P., Roland, G., Bosse, C., & Zayas, E., *Proceedings of BFY2* (2015).

about E-CLASS: Zwickl, B.M., Hirokawa, T., Finkelstein, N., & Lewandowski, H. J. *Phys. Rev. ST Phys. Ed.*, **10**, 010120, 2014.

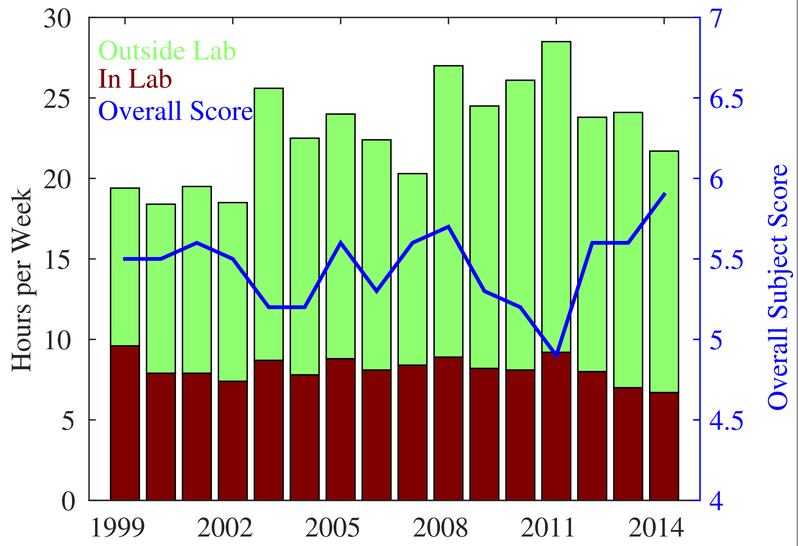
Strategy & Methods

Hypothesis: If students come to lab primed and prepared to learn, they will make more effective use of lab time and contact hours with "expert" teachers, leading to less total hours spent on course, better learning outcomes, more expert attitudes, and higher satisfaction with and enrollment in advanced lab courses.

- Maintain **hands-on lab work** and **professional-style communication** as the core of the learning experience.
- Use edX: **"flip the classroom, not the lab"**
  - Translate existing lab guides into online format.
  - Translate "prep questions" into edX-gradable form
    - students get instant feedback
    - students are primed before coming to lab
- **Online content** & **in-class activities** replace lectures (data analysis, equipment basics, communication technique).

Metrics & Results

- **Enrollment trends**: no measurable effect yet
- **Standard end-of-semester surveys**:



Goal: decrease excessive hours/week spent on coursework, increase student satisfaction. Averages of standardized end-of-semester student survey results. Notable improvement in both metrics starting with initial interventions in 2012. Further improvements appear with the fully flipped implementation in 2013.

Some notable improvements!

- **E-CLASS**:
  - Potentially most exciting set of metrics! But . . .
  - . . . most data for large-statistics semesters not yet analyzed. Only coarsest metrics examined so far.
  - Results: no measurable effects so far.
- **Special surveys**: not yet analyzed.

about Junior Lab (MIT subjects 8.13 & 8.14)

- Learning goal: **professional and personal development of the student as a scientist**
  - laboratory technique and topics in modern physics
  - oral and written communication methods
  - the troubleshooting process
  - professional scientific attitude
  - data analysis
  - reasoning about uncertainty
- **Two-semester lab sequence**
  - 8.13 required for most majors: ≈ 70 students per year
  - 8.14 *not* required for most majors: ≈ 20 students per year
- Experiments in (mostly) **modern physics**
  - 4–6 three-hour lab sessions per experiment
  - stand-alone course; no lecture
  - students work in pairs
  - preparatory reading & questions before each experiment

8.13 Experiments	8.14 Experiments
Preliminary Experiments	Doppler-Free Saturation Spectroscopy
Atomic Spectroscopy	Mössbauer Spectroscopy
Compton Scattering	Optical Pumping
Cosmic Ray Muons	Optical Trapping
Frank-Hertz	Pulsed NMR
Johnson and Shot Noise	Quantum Information
Optical Trapping	Radio Astronomy
Pulsed NMR	Superconductivity
Radio Astronomy	X-Ray Physics
Relativistic e/m	*Exploratory Project*
Rutherford Scattering	
X-Ray Physics	

- **Communication intensive**: each experiment
  - 4-page *Phys. Rev.* style written summary, *and*
  - 15-minute conference-style presentation to faculty
- **Not a "gateway to research" course**
  - Students already have research experience
  - Learn **authentic but generalized** modes of practice
  - Complements unstructured setting of research experiences

Conclusions

- Survey results are promising, but subjective.
- Nothing quantitative yet regarding learning or enrollment.
- **Faculty like what they're seeing in lab performance.**
- More data and more analysis are needed.