Flipping science lab courses with portable sensors

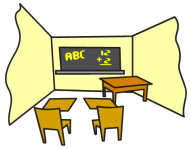
Forrest Bradbury

Lecturer at Amsterdam University College

Flipping science lab courses with portable sensors

idea: flipped classroom meets open-inquiry lab

money: NWO Comenius Fellows grant (1 year, 50k euro)



course: “Maker Lab” (6 EC, Feb-May 2020)

Forrest Bradbury

Lecturer at Amsterdam University College

Flipping science lab courses with portable sensors

<u>the Comenius Project team:</u>

- Freek Pols (TU Delft)
- Paul Vlaanderen (UvA, PPMproductions)
- Jasper Homminga (TU Twente and its university college)

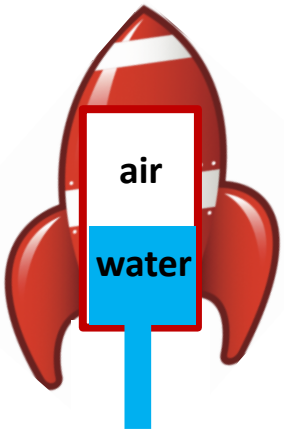
Forrest Bradbury

Lecturer at Amsterdam University College

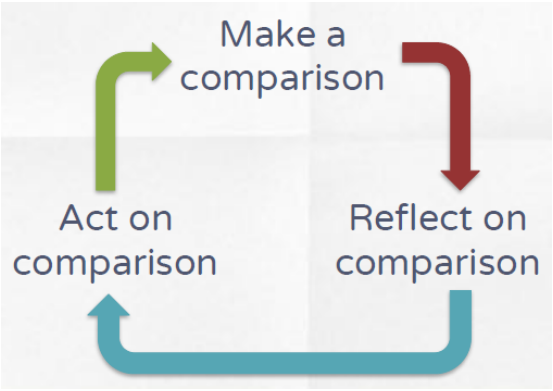
Flipping science lab courses with portable sensors

outline:

AUC context



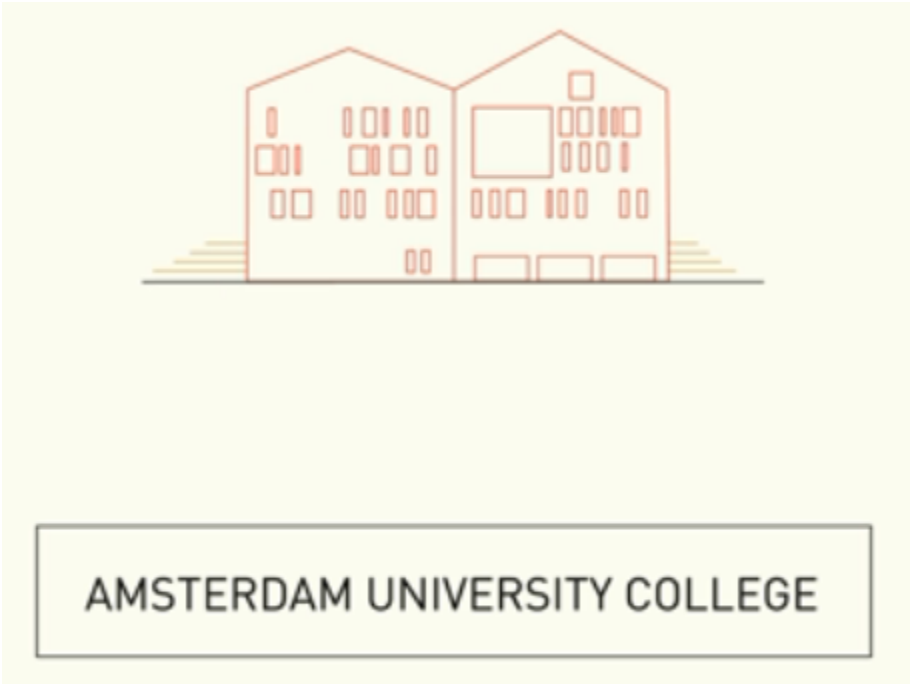
Some experience



Intriguing literature

Flipping science lab courses with portable sensors

in the context of AUC's program:



promotional film:

http://www.auc.nl/about-auc/about-auc.html

Flipping science lab courses with portable sensors

in the context of AUC's program:

- general:
  - small group sizes (≤25)
  - higher admission requirements
  - higher tuition

- "Maker Lab" is an *interdisciplinary* natural science lab course

- AUC has:
  - no lab facilities/rooms ☹ , except the "Maker Lab Closet" ☺
  - separate 2nd year disciplinary (e.g. physics) lab courses ☺
  - separate statistics and modeling courses ☺
  - students with above-average motivation ☺

Flipping science lab courses with portable sensors

my previous experience: the Rocket Project

Timeline:

Seven 90 min. classes (out of 30)
in 6 EC Classical Mechanics course (thus nearly 1.5 EC)

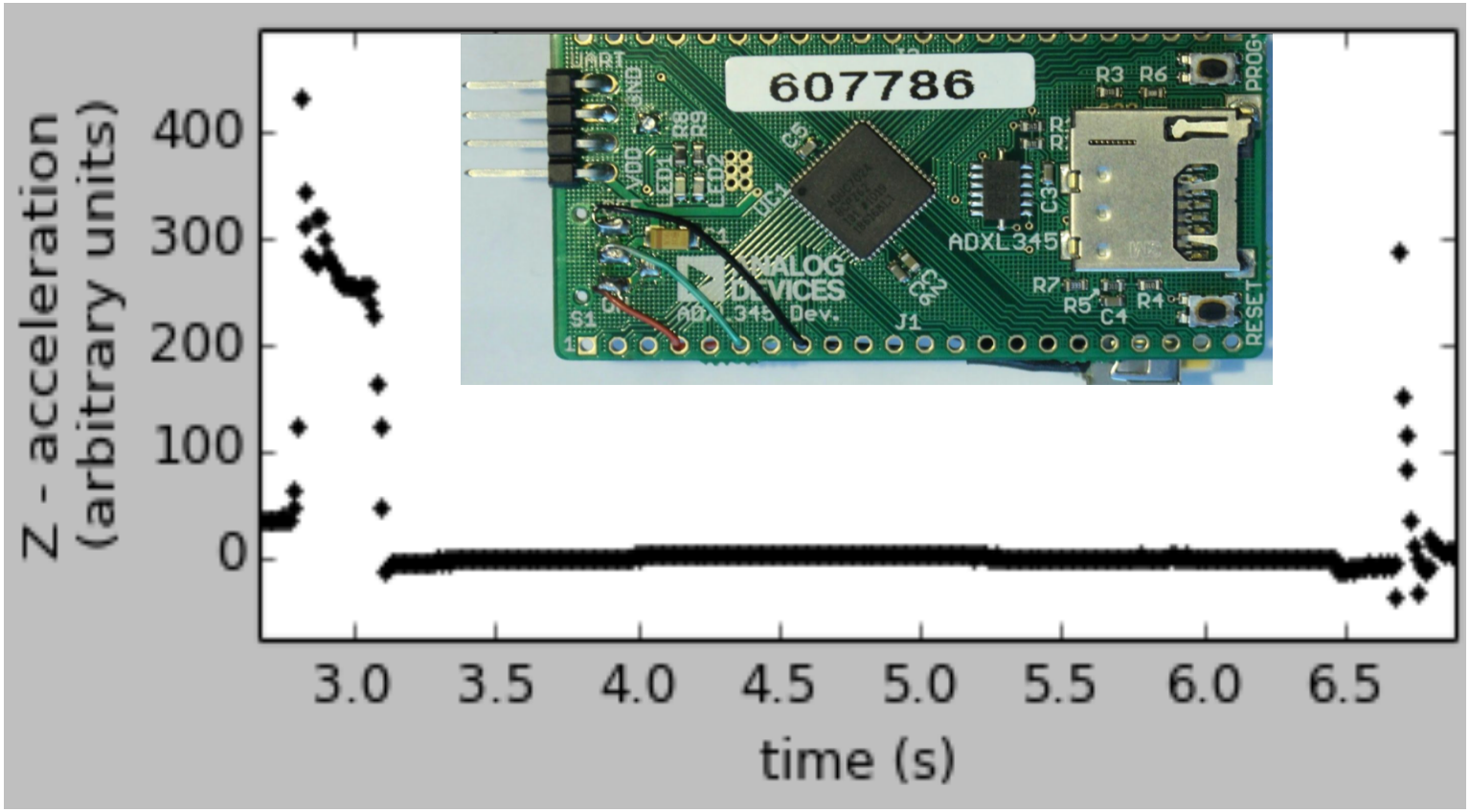
	Activities:	**Deadlines:**
16-Oct	Hands-on modeling lecture	Teams (of 3) announced at the end of lecture
20-Oct	Theory lecture on fluid mechanics	
23-Oct	Theory lecture on thermal expansion	
27-Oct	Modeling Q&A session	
30-Oct	Intro to accelerometer measurements	RocketLab model (numerical simulation) due
3-Nov	Accelerometer calibration	
5&6-Nov	Rocket launch!	
13-Nov		RocketLab report due, including updated model

Hardest part: getting them to code and create numerical models

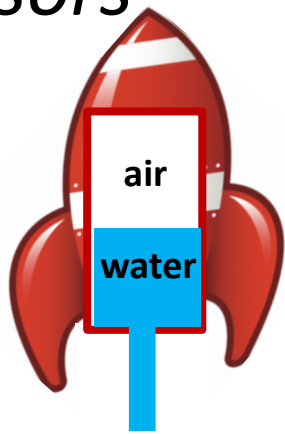
Flipping science lab courses with portable sensors

my previous experience: the Rocket Project

Highlight: deciphering raw accelerometer data



Flipping science lab courses with portable sensors



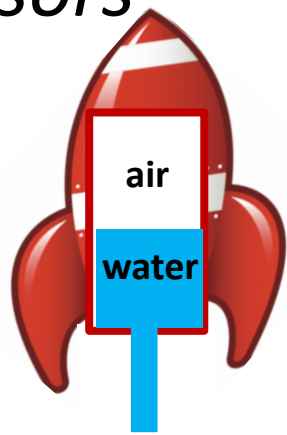
my previous experience: the Rocket Project

6 iterations

...

in which I think my instruction and materials improved dramatically!

Flipping science lab courses with portable sensors



my previous experience: the Rocket Project

Observation:
despite big "improvements" in my instruction,
work of subsequent iterations of students never improved

Why was the first batch so special?

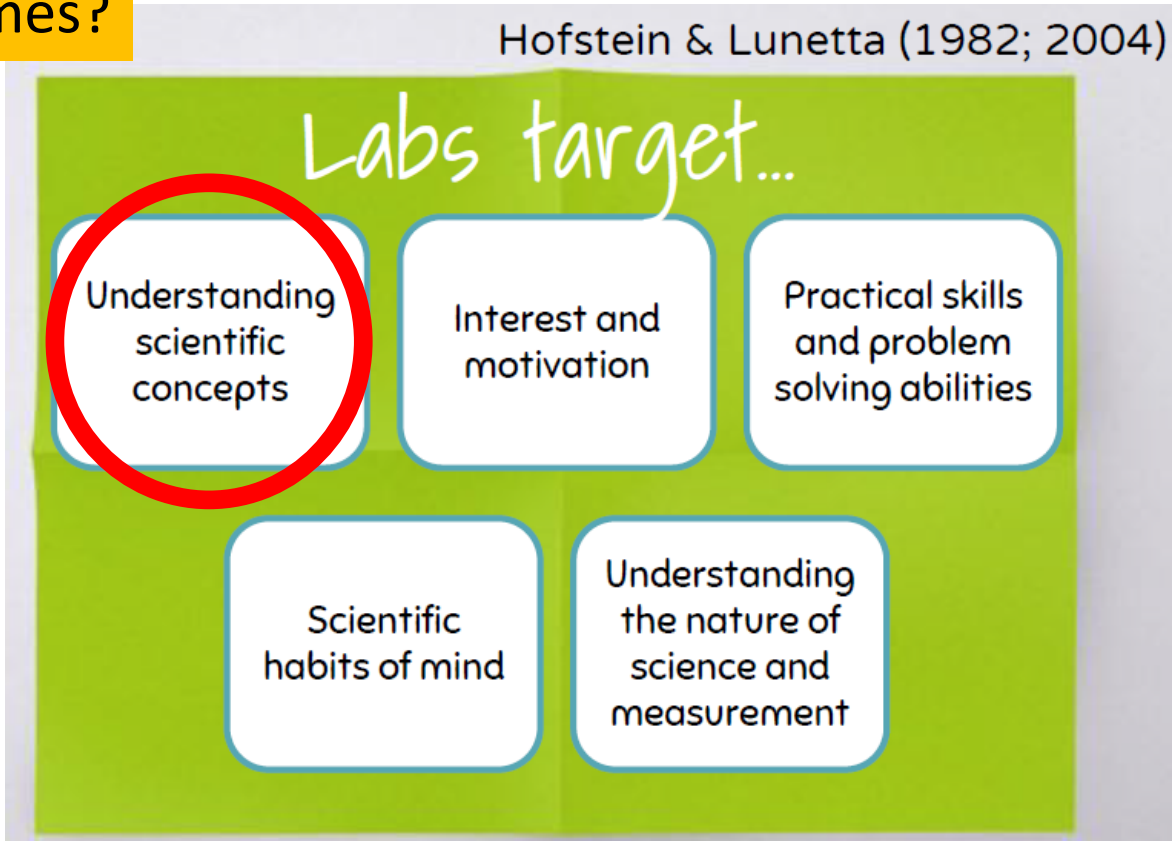
- Was it the novelty?
- The ownership?
- The challenge?

What does the literature say about effective lab courses?

Flipping science lab courses with portable sensors

literature on improving physics labs:

Intended learning outcomes?

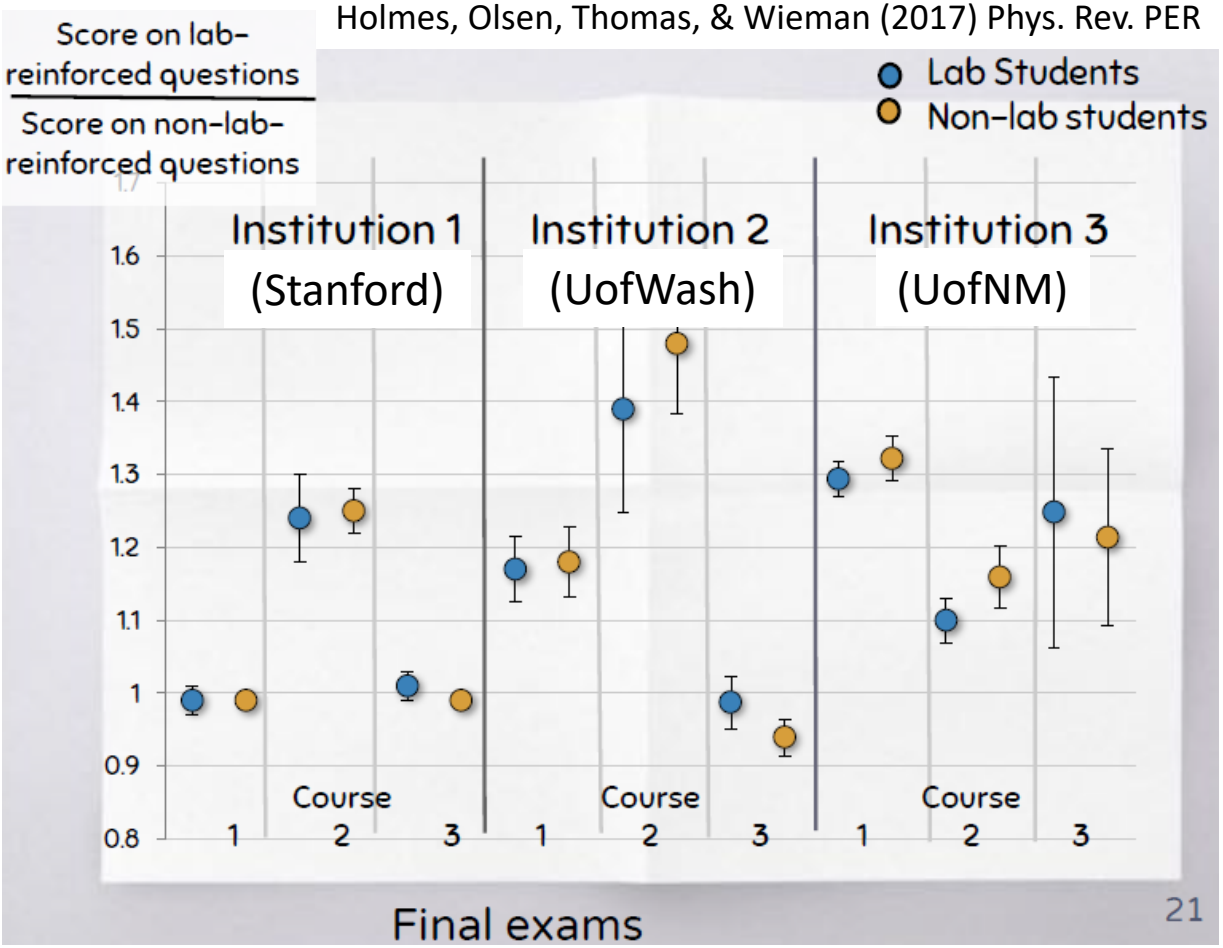


Slides from Cornell Professor Natasha Holmes' AAPT New Faculty Workshop presentation, 2017
https://www.aapt.org/Conferences/newfaculty/upload/170621_Holmes_Labs-1.pdf

"Flipping" a physical science lab course

literature on improving physics labs:

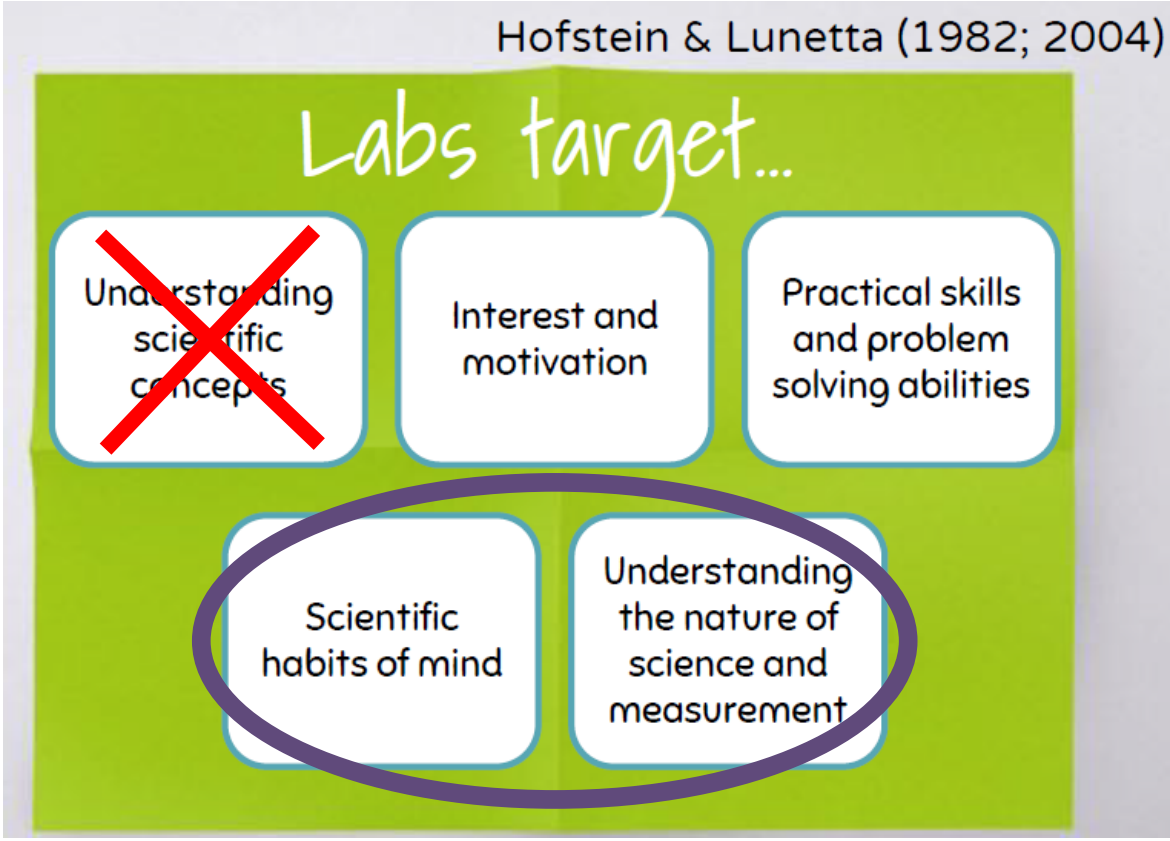
Holmes, Olsen, Thomas, & Wieman (2017) Phys. Rev. PER



Slides from Cornell Professor Natasha Holmes' AAPT New Faculty Workshop presentation, 2017
https://www.aapt.org/Conferences/newfaculty/upload/170621_Holmes_Labs-1.pdf

Flipping science lab courses with portable sensors

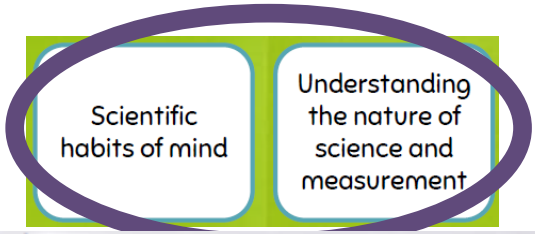
literature on improving physics labs:



Slides from Cornell Professor Natasha Holmes' AAPT New Faculty Workshop presentation, 2017
https://www.aapt.org/Conferences/newfaculty/upload/170621_Holmes_Labs-1.pdf

Flipping science lab courses with portable sensors

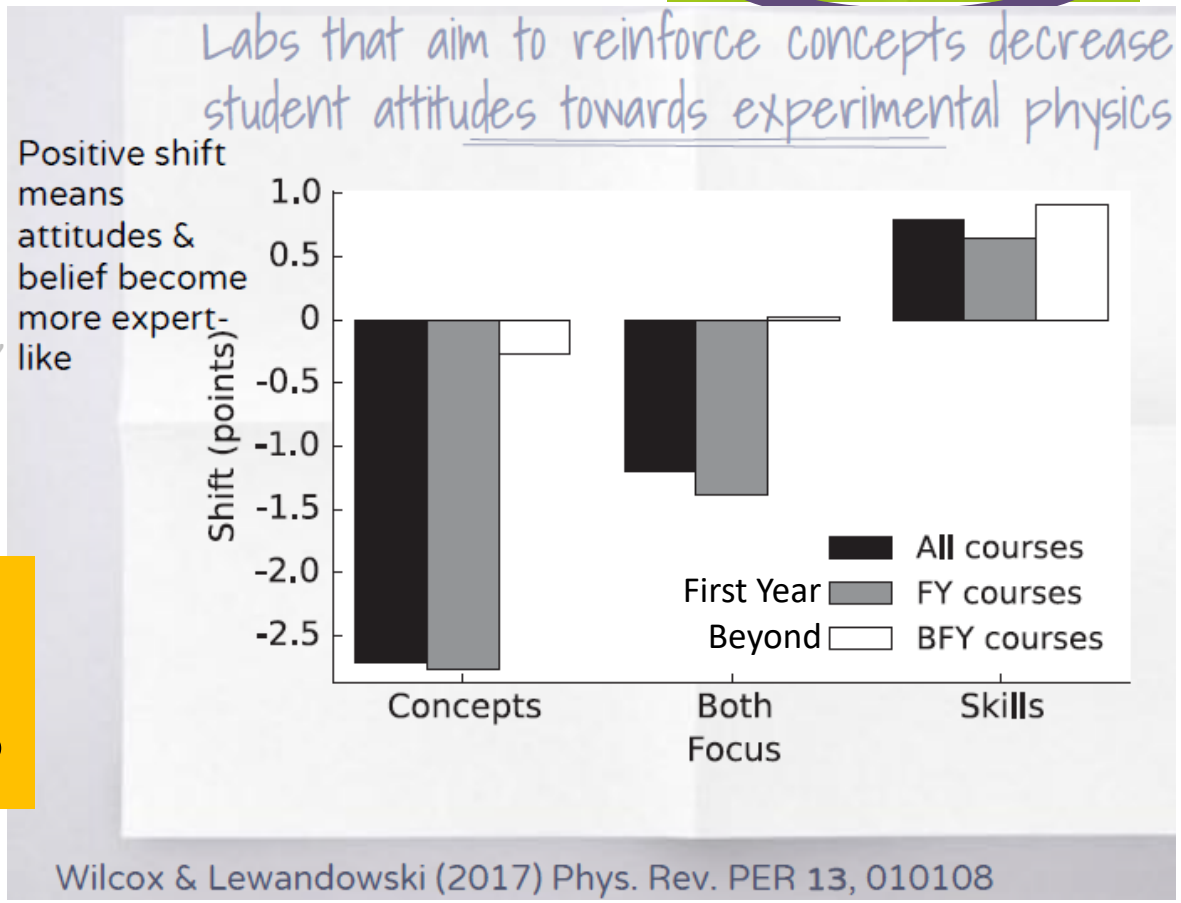
literature on improving physics labs:



"E-Class":
Colorado Learning Attitudes about Science Survey for experimental physics

Zwickl, Hirokawa, Finkelstein & Lewandowski, Phys Rev Spec Top - Phys Educ Res 10(1):10120 (2014).

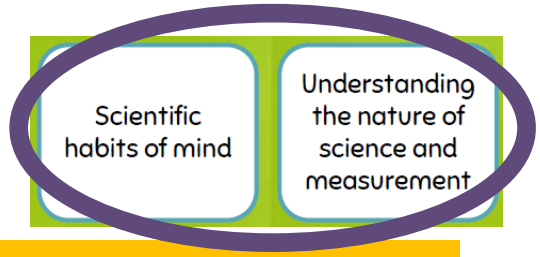
Are students' attitudes and beliefs aligned with those of expert physicists?



Slides from Cornell Professor Natasha Holmes' AAPT New Faculty Workshop presentation, 2017
https://www.aapt.org/Conferences/newfaculty/upload/170621_Holmes_Labs-1.pdf

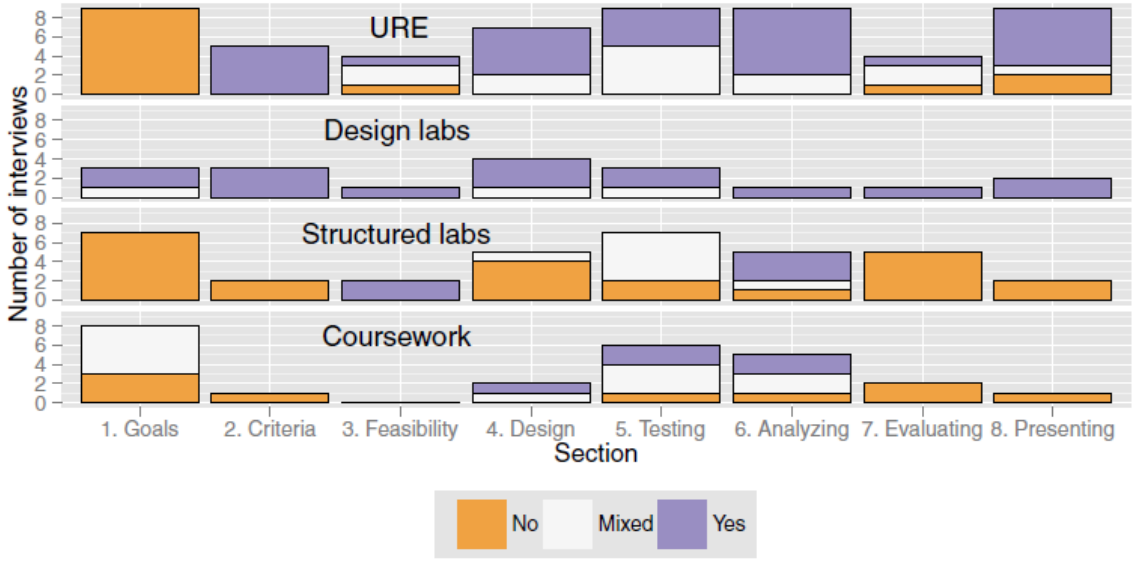
Flipping science lab courses with portable sensors

literature on improving physics labs:



When openly questioned, what do the students say they are doing?

(EPCTA = Experimental Physics Cognitive Task Analysis)



Cognitive Task Analysis Elements

1. Establishing research goals
2. Defining criteria for suitable evidence
3. Determining feasibility of experiment
4. Experimental design
5. Construction and testing of apparatus/code
6. Analyzing data
7. Evaluating results and analyzing implications
8. Presenting the work

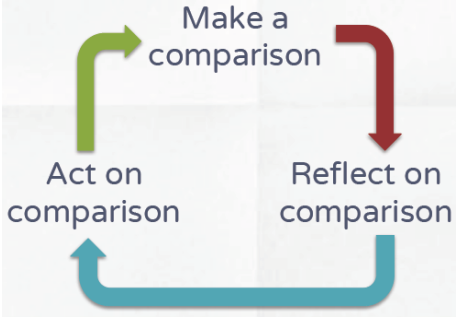
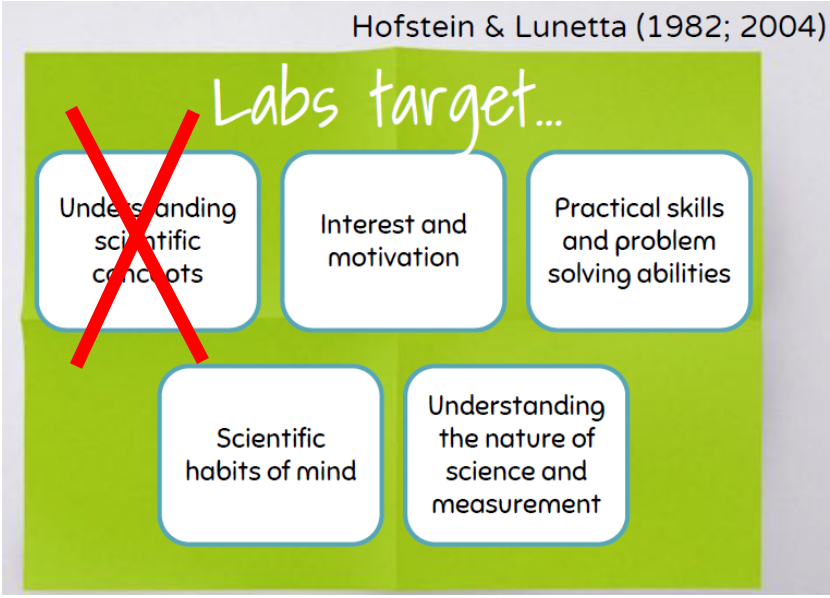


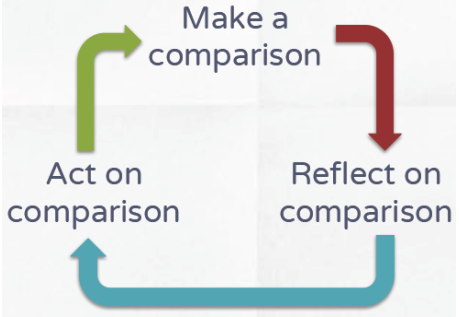
FIG. 3. Fraction of interviews in which the EPCTA elements were discussed in the context of URE, class work, or the structured or design lab courses. Comments were categorized as Yes (students were performing this task), No (students were not performing this task), or Mixed (some students were and others were not).

Flipping science lab courses with portable sensors

literature on improving physics labs:

Analysis: aside from "practical skills", learning outcomes may be best served by open-inquiry "Design labs"





Slides from Cornell Professor Natasha Holmes' AAPT New Faculty Workshop presentation, 2017
https://www.aapt.org/Conferences/newfaculty/upload/170621_Holmes_Labs-1.pdf

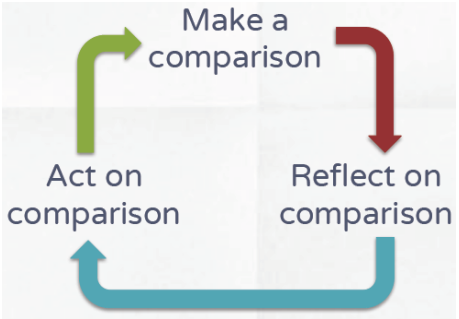
Flipping science lab courses with portable sensors

literature on improving physics labs:

"Research cycle" design labs:
big financial and logistical hurdles !

Professor Holmes' Summary:

- Labs offer opportunity to teach critical thinking and experimentation skills (with suggested limits to how well they teach physics concepts)
- SQILabs use deliberate practice with cycles of comparisons and making decisions to develop students' critical thinking skills
- Other pedagogies and things to check out:
  - Investigative Science Learning Environments (studio/workshop, Rutgers)
  - iOLab (pocket device students can take home, UIUC)
  - Teaching measurement and uncertainty the GUM way (Cape Town)



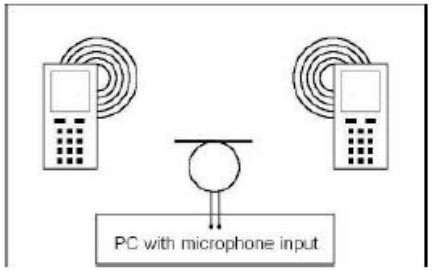
Slides from Cornell Professor Natasha Holmes' AAPT New Faculty Workshop presentation, 2017
https://www.aapt.org/Conferences/newfaculty/upload/170621_Holmes_Labs-1.pdf

Flipping science lab courses with portable sensors

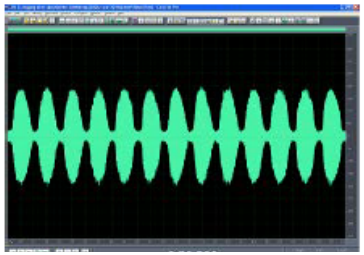
literature on improving physics labs:

Mobile phones as portable sensors?

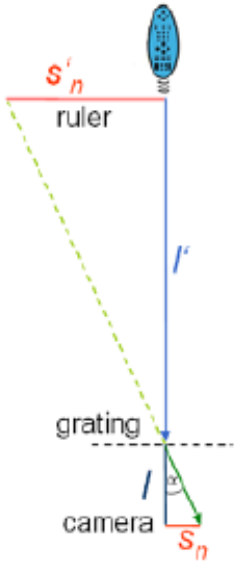
J. Kuhn & P. Vogt, "Applications and Examples of Experiments with Mobile Phones and Smartphones in Physics Lessons", Frontiers in Sensors 1,67(2013)



acoustic Doppler shift for measuring "g"



imaging a remote control's IR interference pattern for determining its frequency



Flipping science lab courses with portable sensors

plans: tools and the maker movement

our choice for enabling open-inquiry:

sensors
controlled by the
Arduino Uno:

and data analysis and lab reports
with Python Jupyter notebooks

Flipping science lab courses with portable sensors

plans: course schedule & assessment structure

6 EC Maker Lab Schedule:

First 7 class sessions:

Structured experiments training
Maker & Experimental Skills

Two sets of 11 class sessions:

Open-inquiry experiments

In total:

29 sessions of 90 minutes
15 weeks with 2 sessions per week
44 of the 168 are contact hours

Each open-inquiry experiment

Follows Wieman's research cycle:

Cognitive Task Analysis Elements
1. Establishing research goals
2. Defining criteria for suitable evidence
3. Determining feasibility of experiment
4. Experimental design
5. Construction and testing of apparatus/code
6. Analyzing data
7. Evaluating results and analyzing implications
8. Presenting the work

Assessments:

- proposal form
- mid-way pitch (graded)
- final poster presentation (graded)

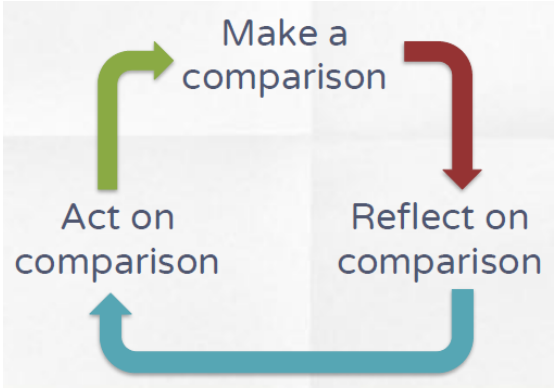
Flipping science lab courses with portable sensors

<u>conclusions:</u>

- no results to report yet…
- the motivations:

AUC context

Some experience



Intriguing literature

Thanks for your attention! *questions / comments?*