Rethinking introductory physics laboratories (both remote and in person) in light of recent interactive technologies and developments in Physics Education Research (PER)

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1 Introduction

The theme of effectiveness of introductory physics laboratories has been object of much published PER research in the last years. In high school and, often, also at University level, the main objective of the introductory labs is to reinforce the understanding of the concepts explained at lessons. The traditional format of labs is in many cases the «cookbook» format, in which very detailed instructions are provided to students.

The availability of new, low-cost and pervasive technologies and the evidence of the effectiveness of new teaching and learning methods, supported by PER, neurosciences and cognitive research, suggest some important changes.

The pandemic of COVID-19 has further highlighted this subject with the need of remote teaching and remote lab activities.

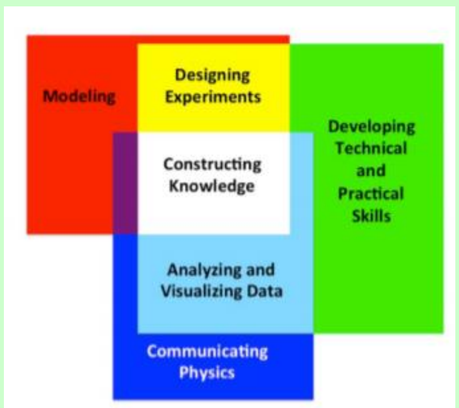
2 Project Research Questions

In the research project I will try to answer to some important questions:

- What are the objectives of the introductory labs students should learn?
- how to help in service and future high school teachers in these goals?

Specifically:

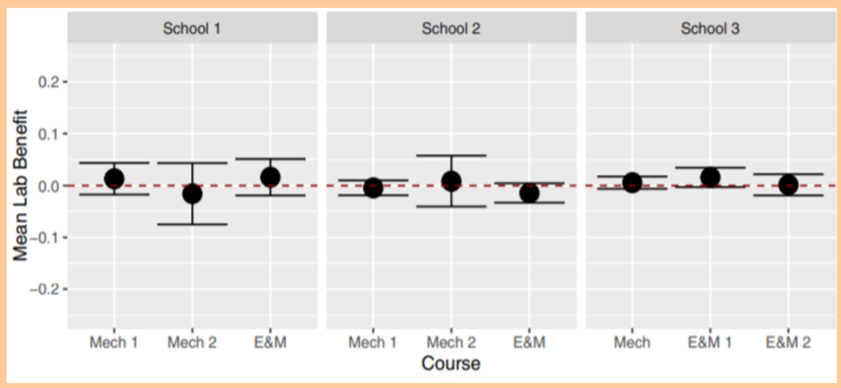
- How to improve the student attitudes and engagement in the laboratory?
- how to improve and develop the scientific skills of students?
- how to engage and support students in the **emergency remote teaching** (COVID-19 pandemic)?



[AAPT Lab Recommendations]

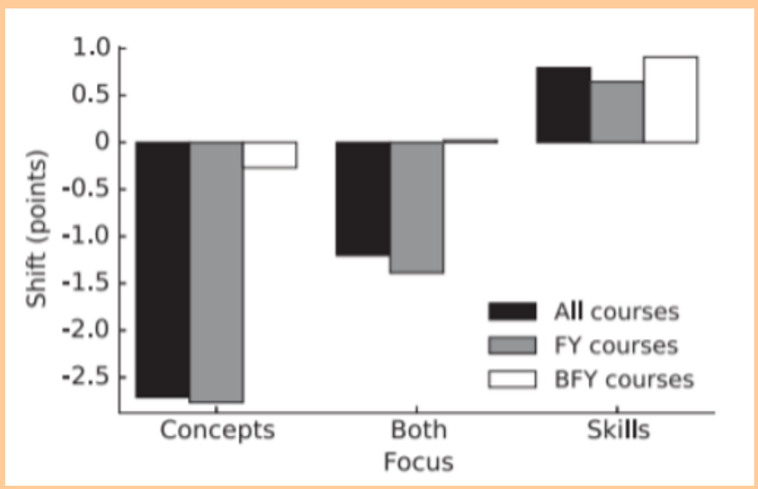
3 Problems in Introductory Labs according to recent PER research

Traditional introductory labs (oriented to reinforce the concepts explained at lesson) show “no added values to learning course content”



> “In a Traditional structured lab, students are told what to do and how to do it.” [Holmes and Wieman, Physics Today, 2018]

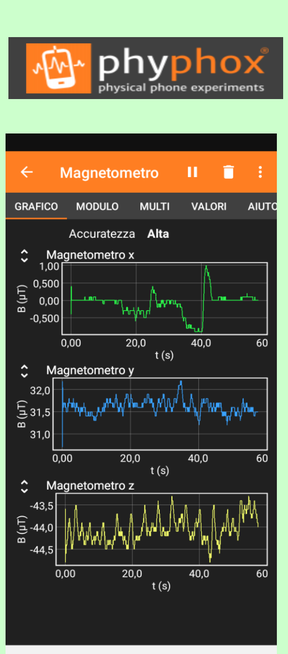
The E-CLASS (*Colorado Learning Attitudes about Science Survey for experimental physics survey*) for the traditional labs shows a decrease in expert-like attitudes of students at the end of labs…



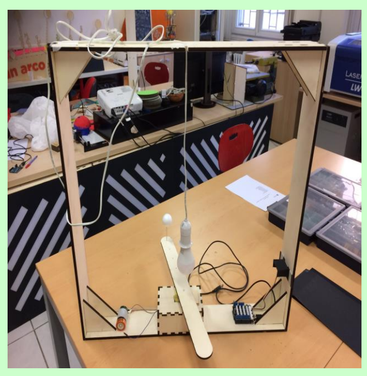
[Wilcox, Lewandowski, 2017]

4 Tools: New interactive tecnologies

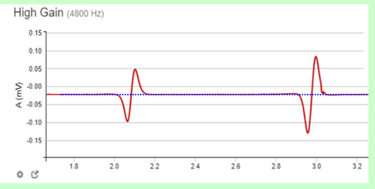
- Virtual labs, simulation tools, Coding, Remote Control of Lab
- Devices with sensors: Smartphone app (phyphox), Arduino, iOLab



Magnetomer to estimate the magnetic field



Simulation with light sensor controlled by Arduino of transit method for the search of exoplanets



Faraday-Neumann’s Law

5 First Steps

I will investigate some coherent frameworks for **active learning**, in particular the ISLE Environment, that is focused on the principle: **“learning within a discipline should resemble the practise of that discipline”.** [Etkina, 2015]

Consequently, the following points will be developed:

- Inquiry based lab activities where students can make some experimental decisions and they do not know the expected outcome;
- project based lab activities using smartphone and Arduino (BYOD) to make measurements at home (**emergency remote teaching**);
- analysis and accommodation of lab kit sent to students;
- developing computational activities to supplement the lab activities (measurements with devices sensors) with simulations with Glowscript and VPython [Chabay & Sherwood, 2008]

Implementation

- Propose the activities to in service and future teachers of University courses;
- elaborate specific rubrics to evaluate and to guide the work done by students;
- **measure** and **compare** the learning results with pre-lab and post-lab surveys (both quantitative and qualitative), test and interviews

References

[Holmes and Wieman] C. Wieman, N.G. Holmes, Physics Today 71, (2018)
[Wilcox et al.] B. Wilcox, H. Lewandowski, Phys. Rev. Phys. Educ. Res. 13, (2017)
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[Wilcox et al.] B. Wilcox & M. Vignal, Phys. Teach. 58, 374 (2020)
Etkina] E. Etkina, Am. J. Phys. 83.8 (2015)
[Chabay & Sherwood] R. Chabay and B. Sherwood, American Journal of Physics **76**, 307 (2008)

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