A department-wide study on the development of students' attitudes toward experimental physics: setting the groundwork for innovation

Marta CARLI, Davide CARUSO

University of Padua, Department of Physics and Astronomy, via Marzolo 8, 35131 Padova, Italy

Abstract. As part of a department-wide effort to enhance instructional laboratories, we are implementing the E-CLASS survey across undergraduate and advanced laboratory courses in Physics and Engineering programs at our institution. Our goal is to understand the current landscape of our laboratories in terms of students' attitudes towards experimental physics and to identify differences among student populations. Preliminary data from a subset of courses offer promising insights, which will form the ground for evidence-based innovations. The study contributes to the emerging research on the innovation of university-level laboratories in the European context.

Introduction

The innovation of instructional laboratories is a hot topic in Physics Education Research (PER). While significant research exists in the US context [1], there is a recognized need for further exploration within Europe [2]. As part of a department-wide effort to enhance instructional laboratories at our university, our group has been involved in sharing PER findings with colleagues, supporting the formation of a faculty learning community, and identifying tools to enable assessment of innovations. This contribution describes our baseline implementation of the E-CLASS survey in academic year 2023/24. The aim was to assess the current state of instructional physics laboratories at our institution, laying the groundwork for tailored innovations. The project includes three categories of laboratory courses: undergraduate physics laboratories, advanced physics laboratories, and the laboratory component of introductory physics courses for engineers.

Theoretical framework

The *Colorado Learning Attitudes about Science Survey for Experimental Physics (E-CLASS)* [3] is used to evaluate students' attitudes towards experimental physics and their expectations regarding course grades. Developed at the university of Colorado Boulder, it compares students' answers to pairs of questions (What do *you* think while doing experiments for class? What would *experimental physicists* say about their research?), covering various aspects of physics experimentation. The results have been used to generate data about the type of laboratories that best enhance students' attitudes towards experimental physics [1], to identify specific learning goals to be targeted in a course [2], and to discern differences among student groups [4]. In the context of our project, we are using the E-CLASS to answer the following research questions: *What is the current landscape of our laboratories concerning students' attitudes towards experimental physics? What differences exist among student populations targeted by our courses?*

Methods and findings

For this project, we are using the validated Italian version of the E-CLASS for undergraduate courses and the original English version for advanced courses. To gain further insights into the results, we coupled the ECLASS with survey questions on students' gender, belonging to underrepresented groups, and physics identity [5]. The survey is made available to students via the

university learning management system. Due to GDPR restrictions, the survey was kept anonymous; to enable pre/post matching, we followed the same method as in Teichmann et al. [2]. Instructors were asked to compile the ECLASS pre-instruction survey.

At the time of submission of this abstract, we have collected pre/post data from two 2nd-year BSc Engineering courses, the 2nd-year lab course of the BSc Physics program, and the 1st-year lab courses of the MSc Physics program (figure 1). The complete dataset, including post-course data from annual courses and pre/post data for 2nd-semester courses, will be available by June 2024.

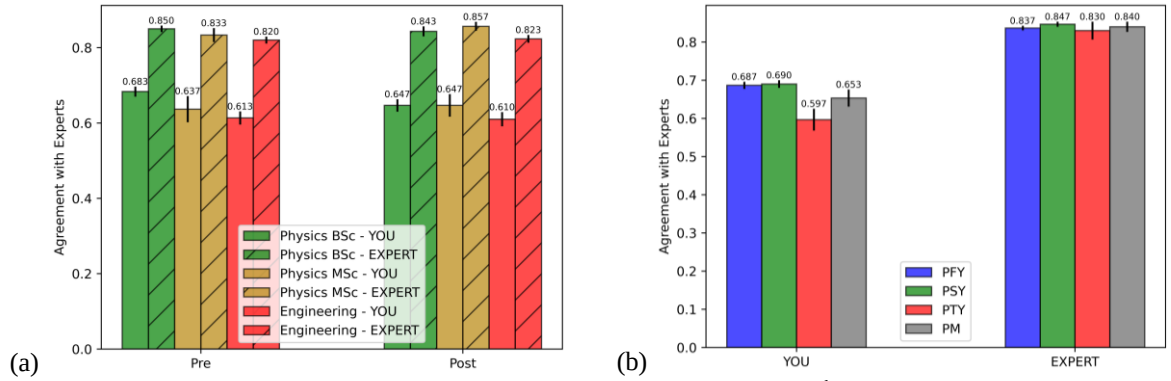

Fig. 1. (a) Pre/post global ECLASS results for the three samples of students (2nd-year Physics BSc, 1st-year Physics MSc, 2nd-year Engineering BSc), first-semester courses. (b) Pseudo-longitudinal, pre-test global ECLASS results for the different cohorts of Physics students (1st, 2nd, and 3rd year BSc, 1st year MSc).

Conclusions

The findings reveal interesting features, trends, and group differences within our institution's laboratory courses. The full dataset will offer deeper insights into our research question, particularly with the inclusion of analysis on expectations and identity-related questions. These results will serve as an evidence-based foundation for the ongoing process of innovation of laboratories within our department. Our study contributes to the emerging research on the innovation of undergraduate and advanced laboratories in Europe. We are actively establishing connections with fellow researchers engaged in this endeavour. We expect that these efforts will contribute to a European community of physics educators and researchers dedicated to the improvement of instructional laboratories, considering the specificities of the European context.

References

[1] B.R. Wilcox and H. J. Lewandowski, Developing skills versus reinforcing concepts in physics labs: Insight from a survey of students' beliefs about experimental physics, *Phys. Rev. Phys. Educ. Res.* **13** (2017) 010108.

[2] E. Teichmann, Lewandowski and M. Alemani, Investigating students' views of experimental physics in German laboratory classes, *Phys. Rev. Phys. Educ. Res.* **18** (2022) 010135.

[3] B.M. Zwickl, T. Hirokawa, N. Finkelstein and H.J. Lewandowski, Epistemology and expectations survey about experimental physics: Development and initial results, *Phys. Rev. Phys. Educ. Res.* **10** (2014) 010120.

[4] N. Sulaiman, A. Werth and H.J. Lewandowski, Students' views about experimental physics in a large-enrollment introductory lab focused on experimental scientific practices, *Phys. Rev. Phys. Educ. Res.* **19** (2023) 010116.

[5] Z.Y. Kalender, E. Marshman, C.D. Schunn, T.J. Nokes-Malach and C. Singh, Why female science, technology, engineering, and mathematics majors do not identify with physics: They do not think others see them that way, *Phys. Rev. Phys. Educ. Res.* **15** (2019) 020148.