Irving K. Barber Faculty of Science / Department of Computer Science, Mathematics, Physics and Statistics

Integrating Discovery and Computational Skills into First-Year Physics Labs

Jordan Sawchuk, Ian Kennedy, Eric Launer, Ammar Zavahir, Anna Nikou, Jordan Andrews, Hiroko Nakahara, Firas Moosvi, and Jake Bobowski

Overview

A comprehensive revision of the lab component of Physics 121 gave us the opportunity to adopt new pedagogical strategies and incorporate new skills. During our revisions, we had two primary goals.

Intregrating Discovery

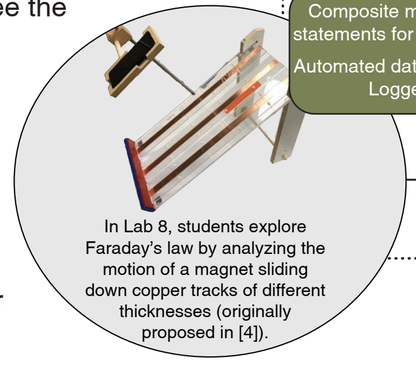
There is a growing body of evidence that confirmational lab activities are ineffective at reinforcing student comprehension of lecture materials [1, 2]. Furthermore, studies have shown that structured labs largely limit student engagement to data analysis and neglect other cognitive tasks frequently encountered by experimental physicists [1]. Our goal was to create labs that would

- impart scientific insights that would be of value to students from all disciplines
- instill a sense of scientific discovery
- demonstrate that meaningful experiments can be done using simple and easily available materials

Integrating Computational Skills

Though scientific computing skills are essential in both academia and industry, UBCO does not yet have a computational physics course. In order to fill this gap, we wrote these labs in Jupyter Notebooks, an open-source interactive coding environment. There are many advantages to using this environment:

- students gain valuable experience with the Python programming language
- auto-grading capabilities give TAs more time to provide detailed feedback to written questions
- quick and easy analysis and visualization of data allows students to immediately see the results of improved experimental methods
- automation of certain repetitive tasks gives students more time to think about relevant physical principles
- digital labs are easy to modify during the term and reduce paper waste

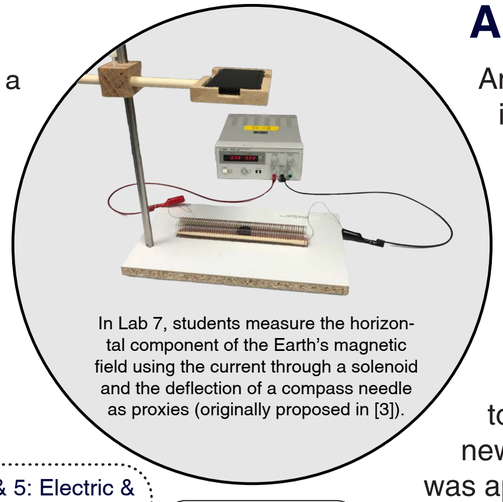


In Lab 8, students explore Faraday's law by analyzing the motion of a magnet sliding down copper tracks of different thicknesses (originally proposed in [4]).

Program Evaluation

In order to evaluate the labs, we collected data from a variety of sources.

- Students completed surveys in the middle of the term and at the end of the term.
- We conducted semi-structured interviews with 8 volunteer students in order to gain more detailed insight
- TAs filled out small survey forms during weekly meetings throughout the term to assess their experiences with each lab

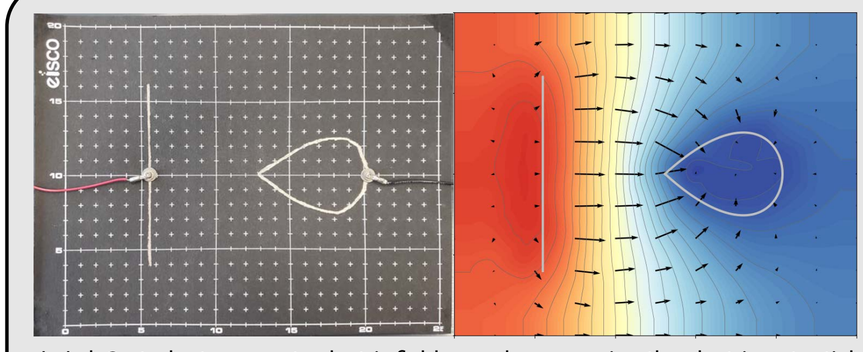


In Lab 7, students measure the horizontal component of the Earth's magnetic field using the current through a solenoid and the deflection of a compass needle as proxies (originally proposed in [3]).

Analysis

Analysis of student responses to surveys and interviews will be completed after the deadline to contest PHYS 121 grades has passed during the summer of 2023. However, based on initial observations and conversations with students and TAs, we have two tentative conclusions.

1. The integration of computational skills into the labs was a success. Students seemed to enjoy the format, and the pace at which new computational methods were introduced was appropriate for students with no prior coding experience. TAs also overwhelmingly preferred the digital format to the previous paper format.
2. We managed to introduce some elements of discovery into the labs, but more work is required to achieve our goals. Going forward, we would like to introduce more opportunities for students to work independently and make unexpected observations.



In Lab 3, students generate electric field maps by measuring the electric potential across a sheet of carbon paper with a variety of designs of conducting paint

Acknowledgements

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References

[1] Holmes et al., Phys. Rev. Phys. Educ. Res. 13, 010129 (2017).
[2] Holmes and Wieman, Phys. Today 71, 38 (2018).
[3] Stewart, Phys. Teach. 38, 113 (2000).
[4] Molina-Bolivar, Eur. J. Phys. 33, 697 (2012).
[5] Bobowski, Phys. Teach. 59, 560 (2021).