Student Perceptions and Performance on an Introductory Physics Laboratory Practicum Assessment

Denver

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Abstract

A growing body of research on laboratory classes has encouraged a shift away from traditional, cook-book, content-validation activities and towards more authentic, inquiry-based explorations. Over the last several years we have reformed our Introductory Experimental Physics courses based on this call. The reformed labs are inquiry-based and divorced from lecture, focusing on experimental skills, modeling, and data analysis. Despite positive responses from students and the instructional team, a consistent issue was the authentic, individual assessment of experimental content knowledge and practical laboratory skills. Here I present the goals and structure of a new laboratory practicum assessment, and report on student performance and reception of the assessment over two semesters of data collection. Note: the practicum is a course-level assessment aligned with the content and learning goals of the reformed labs at UCD, it is **not** a general laboratory concept inventory or validated attitudinal survey.

Course Structure

Week	Lab 1	Lab 2
1	Measurements	Electroscope I
2	Pendulum I	Electroscope II
3	Pendulum II	DC Circuits I
4	Pendulum III	DC Circuits II
5	Pendulum IV	Nichrome Wire
6	Springs I	Lightbulb I
7	Springs II	Lightbulb II
8	Practicum	Practicum
9	Make-up week	Make-up week
10	Free Fall I	Magnetic Fields I
11	Free Fall II	Magnetic Fields II
12	Rotational Motion	Optics I
13	Accelerating Cart	Optics II
14	Freeform I	Freeform I
15	Freeform II	Freeform II

Content and skills are:

- Weeks 1–7: Introduced and Developed
- Week 8: Assessed (Individually)
- Weeks 10–13: Practiced And Extended
- Weeks 14–15: Summative Assessment (+ Experimental Design)

Data Collection

Student Performance

- Practicum Scores, averaged over all tasks and sections
  - Stable over two semesters, accounting for grading change
  - Higher in Lab 2 than Lab 1. See Table 1 at right)

Student Perception

- Practicum Survey, built on Qualtrics – **not** a validated attitudinal survey
  - Students offered extra credit for completion
- Mix of Likert and free-response questions, probing students' perceptions of the content and their experience taking the practicum
- Focus on two "sets" of Likert Questions (Content and Experience)

TABLE II. Content (C) and experience (E) question sets from the practicum survey.

C1	The practicum tested conceptual knowledge based on prior labs
C2	The practicum tested experimental skills based on prior labs
C3	The practicum tested content/skills NOT covered in prior labs
C4	The lab activities prepared me for the practicum
C5	The practicum was a fair assessment
E1	I felt I was well prepared for the practicum BEFORE taking it
E2	I felt I was well prepared for the practicum AFTER taking it
E3	The instructions on the practicum were clear
E4	The practicum was harder than I expected it to be
E5	The practicum was a stressful experience
E6	I'm happy with how I did on the lab practicum
E7	My score on the practicum is a fair reflection of my performance in the lab

Practicum Tasks

The practicum assess:

Experimental Skills
- Two hands-on tasks, sometimes including calculations

Data-Analysis Skills
- "Excel" task, including statistical calculations and the creation/analysis of plots

Basic Content Knowledge
- Four multiple choice questions.

Structure / Timing

- Students cycle through three stations in 30-minute rotations.
- Students call over TA to be graded (out of 5 points) when they are ready ***or*** at the end of 30 minutes.
- Stations are re-set by the LAs between rotations.

Name: ______________

TA: ______________

Section #: ____

PHYS-2341 Lab Assessment

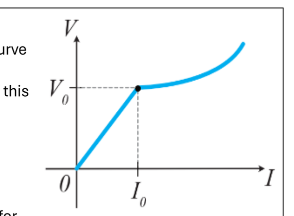
Version A

	FOR TA USE
Station 1: Build a circuit with a lightbulb and a multimeter to measure the current through the lightbulb. Leave your circuit set up for your TA to grade. Sketch a circuit diagram in the space below. When finished, raise your hand for your TA to come grade your work.	
Station 2: You need a wire with a resistance of 3.0 Ohms. Some wire has been provided. What length of wire is needed to achieve the desired resistance? Measure the length and report with units (but not uncertainty) below. Leave your circuit (i.e. measurement) set up for your TA to grade. *Length*: ______________ When finished, raise your hand for your TA to come grade your work.	
Station 3: Follow the instructions provided on the excel sheet open on the Surface tablet. Record your final result in the space below. When finished, raise your hand for your TA to come grade your work. Note: All calculations must be done in Excel. ______________	

Multiple Choice

Write your answer in this column. ↓

1. You collect voltage and current data for a particular electronic device. The V vs. I curve for this device is shown to the right. What can you say about the resistance of this device?

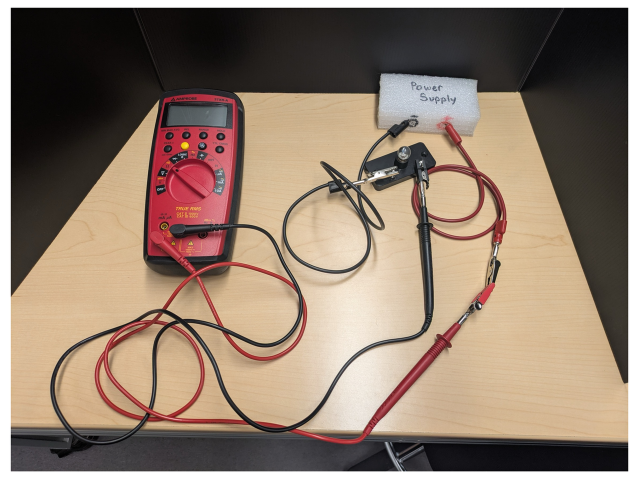


   a) The resistance is constant for currents below I_0, and changes for larger currents
   b) The resistance is changing for currents below I_0, and is constant for larger currents
   c) The resistance for this device is never constant because it is non-Ohmic
   d) You can't say anything about the resistance of the device from this plot
2. After plotting some experimental data and seeing a non-linear trend, which of the following is/are **not** a valid part of the process to find the best fitting model for your data? Select any that apply.
   a) Observe the data to see if it has more than one trend and analyze each part separately.
   b) Make a log-log plot of the data
   c) Compare semi-log and log-log plots to see which offers a more linear fit
   d) Try various trendlines using excel and choose the one with the highest R^2 value.
   e) Make a semi-log plot of the data
3. A group builds a circuit with two ohmic resistors in series. The value of the first resistor is 100 Ohms. The value of the second resistor is unknown. When the voltage is set to 5 Volts, the current in the circuit is 0.02 Amps. What is the value of the unknown resistor?
   a) 100
   b) 150
   c) 120
   d) 15
   e) 250
4. Your group collects X vs Y data and makes a plot of log(Y) vs. log(X). This log-log plot does **not** show a linear trend. What can you say about the relationship between the original X and Y data?
   a) The data follow a power relationship.
   b) The data do not follow a power relationship.
   c) The data follow an exponential relationship.
   d) The data do not follow an exponential relationship.
   e) Nothing can be said about the X and Y data based on this plot.

Example Practicum Stations

LEFT: Lab 1 station: Using a spring of spring constant $k = 20\ N/m$ determine the mass of the washers

RIGHT: Lab 2 station: See "Station 1" on the practicum sheet at left. Bottom shows completed circuit.



Results and Analysis

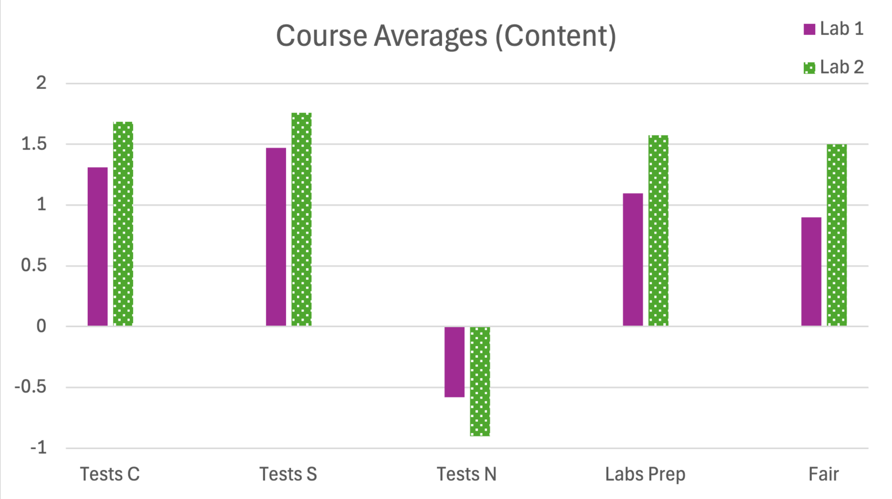
- **Combined**: Full five-point Likert responses (expressed as percentages) are in line with "preferred" responses, indicating that ***students felt the practicum was a fair assessment of the concepts and skills developed in lab, and that it did not test "new" content.***
  - Stronger agreement with C5 (fair test) than with E6 & E7 (pleased with score and score accurately reflects performance in class).
  - "Neutral" would show bars with edges at ± 0.25, so edges between ± 0.25 and ± 0.5 indicate general (dis)agreement, edges beyond ± 0.75 indicate strong (dis)agreement.
- **Course Splits**: Average Likert responses (Strong Disagree = -2, Strong Agree = +2) show identical trend to combined for Lab 2, with Lab 1 showing weaker alignment with "preferred" responses, and overall neutral responses to questions E4-E7. Consistent with lower overall performance score
- **Semester Shifts**: Lab 2 is more stable, with relevant shifts in "preferred" directions, Lab 1 shows larger shifts in general, primarily in preferred direction except for C3.
- This practicum assessment provides a clear, authentic, and well-received course-level assessment of individual students' mastery of basic experimental content and skills. The assessment is tailored to the lab courses at UCD, but the style and structure could be implemented broadly.

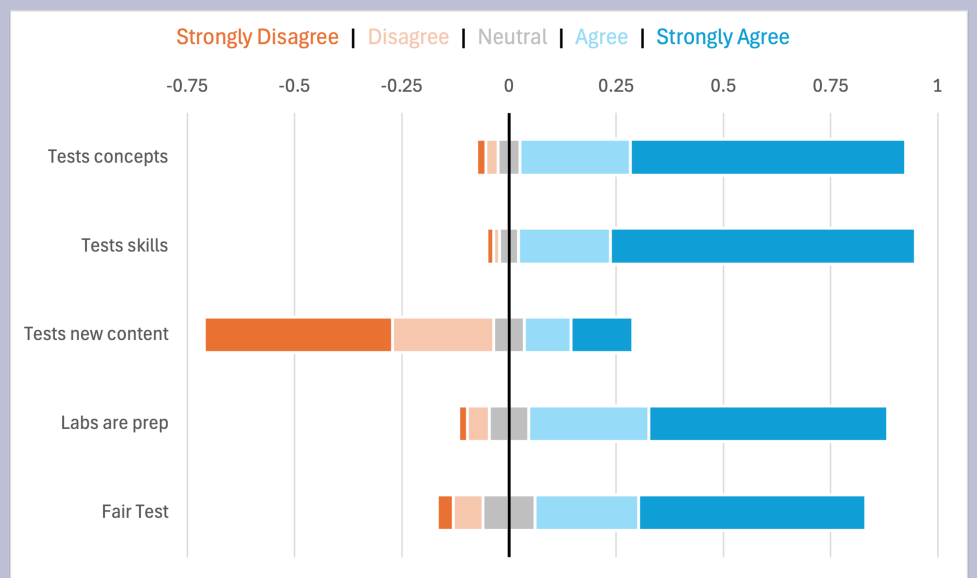
TABLE I. N values and average practicum scores.

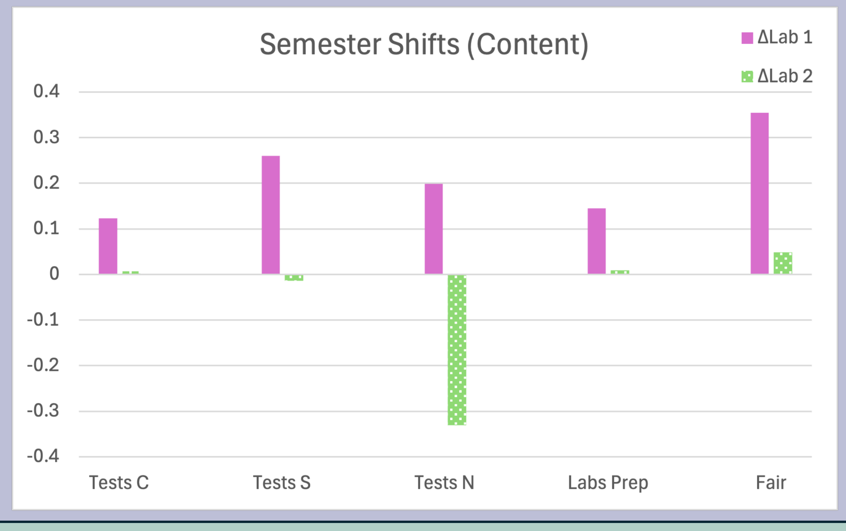
Course	N_{course}	N_{survey}	RR	Score
Lab 1 Sem 1	221	182	82.4%	70.3%
Lab 1 Sem 2	135	106	78.5%	76.8%
Lab 2 Sem 1	105	80	76.2%	84.6%
Lab 2 Sem 2	162	137	84.6%	89.8%
Combined	623	505	81.1%	79.2%

Course Splits | Combined Responses | Semester Shifts

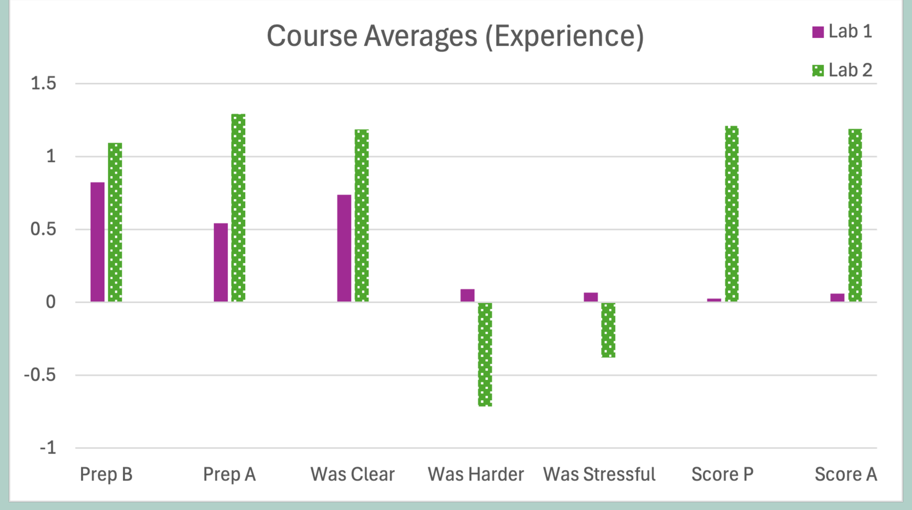
Content

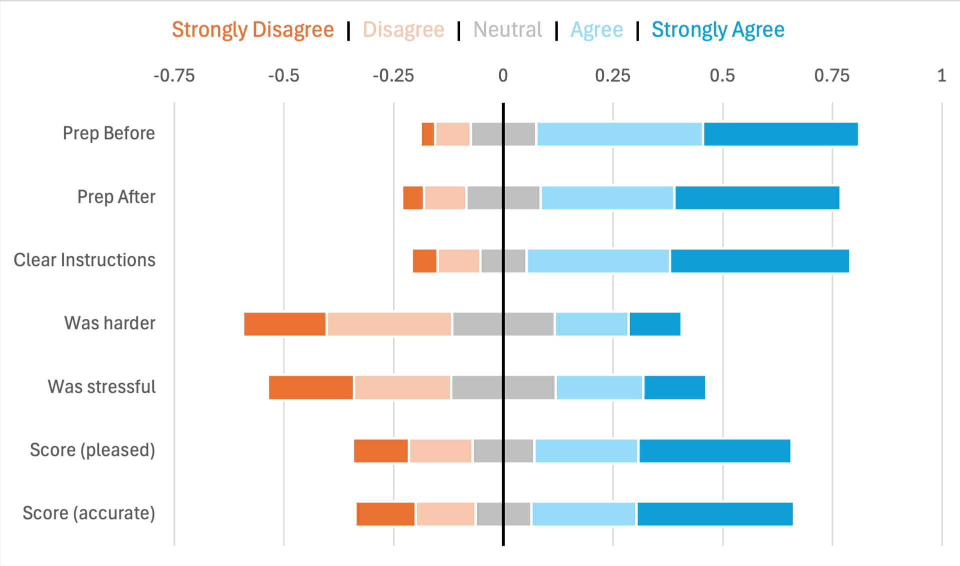


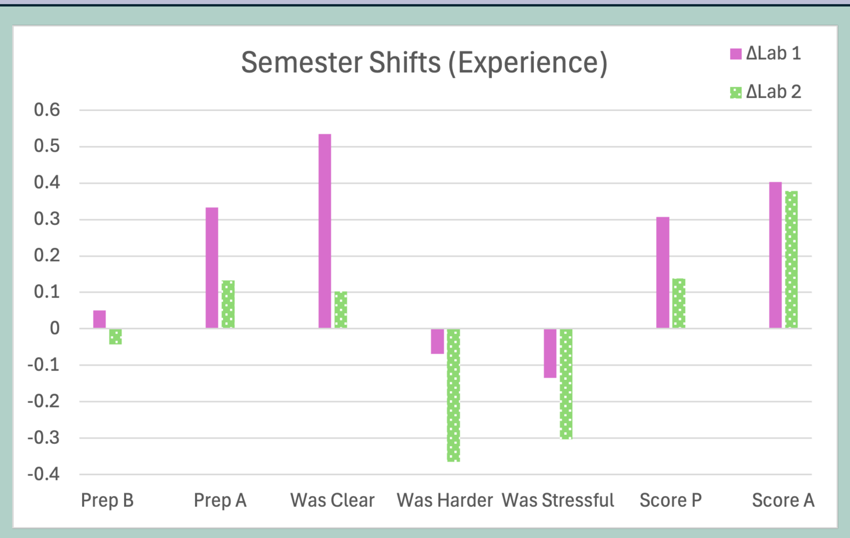




Experience







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