Lab Adaptations for Introductory Physics in an Online Setting

{Emily Tyhurst, Carolyn Sealfon Nariman Khazai }

Course Background

PHY 131/132 is a first year physics course for non-physicists. The enrollment is typically around 800 students at the start of the term, consisting of multiple components of delivery:

1. Three lecture sessions a week
2. "Practical" lab sessions once a week, in groups of 3-4 students
3. Weekly homework assignments, tests
4. **PHY 131:** Kinematics, momentum, energy, force, friction, waves.
5. **PHY 132:** Electricity, magnetism, light, optics.

Technology & Materials

The practical design made use of the following technologies which students had access to:

- **Quercus**, the University of Toronto Canvas site. Most of the course materials were available there.
- **Microsoft Teams Meetings** - The student-facing space for meeting, editing, and sharing files and materials.
- **Microsoft Teams** - Centralized organization for the teaching team for PHY 131/132, sectioned off into practical groups with 12 TAs per day of the week.
- **PhET Simulations** - Web-based applications, usually to demonstrate specific concepts
- **PIVOT Interactives** - ISLE-method developed virtual labs.

Students were provided with a **list of materials** for both terms, which would allow them to complete experiments themselves. For the first term, students were provided with a reimbursement on their tuition in order to purchase the materials. For the second term, students could order a kit directly from U of T physics.

A **video** which illustrates the navigation of this technology is provided with this poster.

ISLE Methodology

The Investigative Science Learning Environment (ISLE) and its intentionalities are summarzied by (Brookes et. al):

- We want students to learn physics by **thinking like physicists**, ie. by engaging in knowledge-generating activities that mimic the actual practices of physics and using the reasoning tools that physicists use when constructing and applying knowledge.
- The way in which students learn physics should **enhance their well-being**.

ISLE Experiment Structure

ISLE identifies three experiment types that we chose to integrate in our Practicals, each of which represent a stage in physicist knowledge-generation:

- **Observational Experiments (O)** - Systematic observations without a hypothesis in mind, designed to collect data and look for potentially interesting patterns.
- **Testing Experiments (T)** - One or more competing physics hypotheses are presented and the experiment must distinguish between the two
- **Application Experiments (A)** - A hypothesis that has been supported by multiple testing experiments is used to scaffold new technology.

PHY 131	PHY 132
O - Kinematics	**T** - E/M Tape
T - Force	**T** - Glasses
A - Friction	**O** - Thin Films
A - Circular Motion (V)	**O** - E/M Induction (V)
T - Momentum (V)	**T** - Circuits (V)

Table 1: Summary of Practicals, in course order. Experiments that were virtual are marked (V)

Collaborative Lab Structure

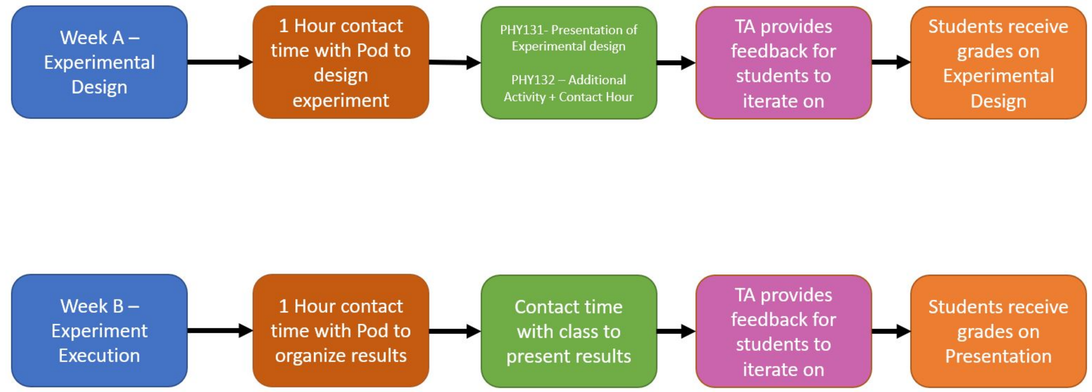

Figure 1: Workflow for the two week structure of the PHY 131/132 practicals. The structure was designed to include ample feedback opportunities. Students are graded based on the Scientific Abilities Rubrics.

Challenges and Future Directions

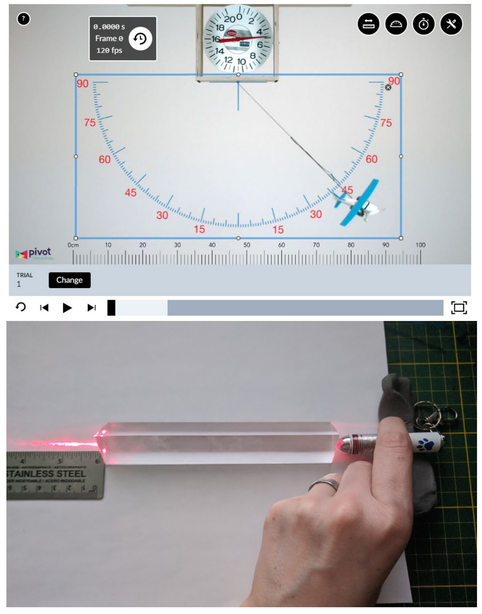

Figure 2: (Top) The virtual experiment environment for vISLE: 4.4, used in PHY 131. The environment allows students to perform multiple trials, and is subject to analog uncertainty in a way that is similar to reality. (Bottom) A PHY 132 optics experiment that needed to be supplemented with TA-provided images and videos due to material delivery challenges.

- Spacing out the presentation and peer-discussions to **two weeks** was effective at sparking discussion and avoiding "Zoom Fatigue"
- Despite the ISLE cycle sequence, onboarding students on **Testing Experiments** first is better for their learning engagement.
- By **design** the hypotheses for testing experiments must admit multiple interesting solutions.
- The online environment is mired by **technology overhead**, thus adding additional systems to the course overall must be weighed heavily against how many systems the students are currently operating with.
- Distribution of materials might be best left to **students** with possible video-experiment recourse.
- In **virtual-only** labs, how do we scaffold good experimental procedure in a way that makes sense? (ie. multiple trials)
- Ongoing challenge: How to involve students collectively in **experimental execution** when they are isolated?