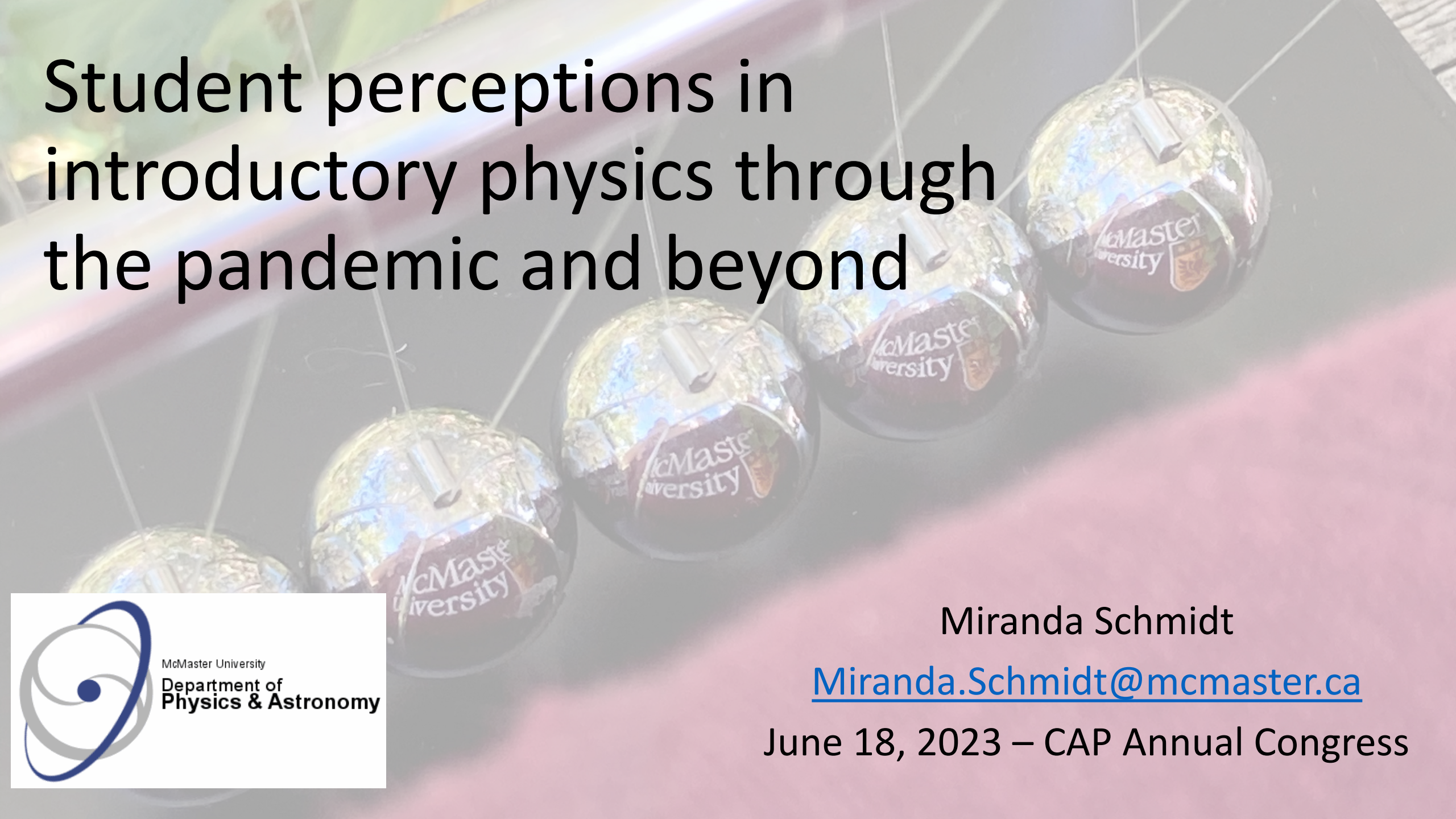
Student perceptions in introductory physics through the pandemic and beyond



McMaster University
Department of
Physics & Astronomy

Miranda Schmidt

Miranda.Schmidt@mcmaster.ca

June 18, 2023 – CAP Annual Congress

Collaborators

- Comparative Study of Introductory Physics Cohorts
  - Dr. Pat Clancy
  - Dr. Cayleih Robertson*
  - Dr. Rob Cockcroft
  - Greg Van Gastel

  - Natalie Pham
  - Thomas Todd
  - Ella Buchnea**
  - Daniel Dobrowolski**
  - Nitara Fernando**
  - Kenzie Lewis**
  - William Marinache

- In-person vs At-home Labs
  - Sara Cormier
  - Dr. Kari Dalnoki-Veress

McMaster University

PAUL R. MACPHERSON INSTITUTE FOR LEADERSHIP, INNOVATION AND EXCELLENCE IN TEACHING

*McCall MacBain Postdoctoral Fellows Teaching and Leadership Program

** funded through the MacPherson Institute Student Partners Program

Comparing Introductory Physics Cohorts and Experiences

Introductory Physics at McMaster University

Introductory Physics

- Algebra based
- No high school physics prerequisite
- ~1400 students/year

Introductory Physics for Chemical and Physical Sciences

- Calculus based
- Grade 12 physics required
- ~80 students/year

Introductory Physics for Engineering

- Calculus based
- Grade 12 physics required
- ~1100 students/year

Students can enter second year Physics & Astronomy programs via all three pathways

Motivation

- We want to better understand the different student cohorts currently taking our introductory physics courses
- We created a series of voluntary, online surveys starting in Fall 2020
  - Initially introductory physics survey administered end of Fall and Winter terms
  - Added beginning of term survey in Fall 2021
  - Can be used to see student perceptions and motivations across each year and between years
  - Can also see how changes to course delivery affect responses

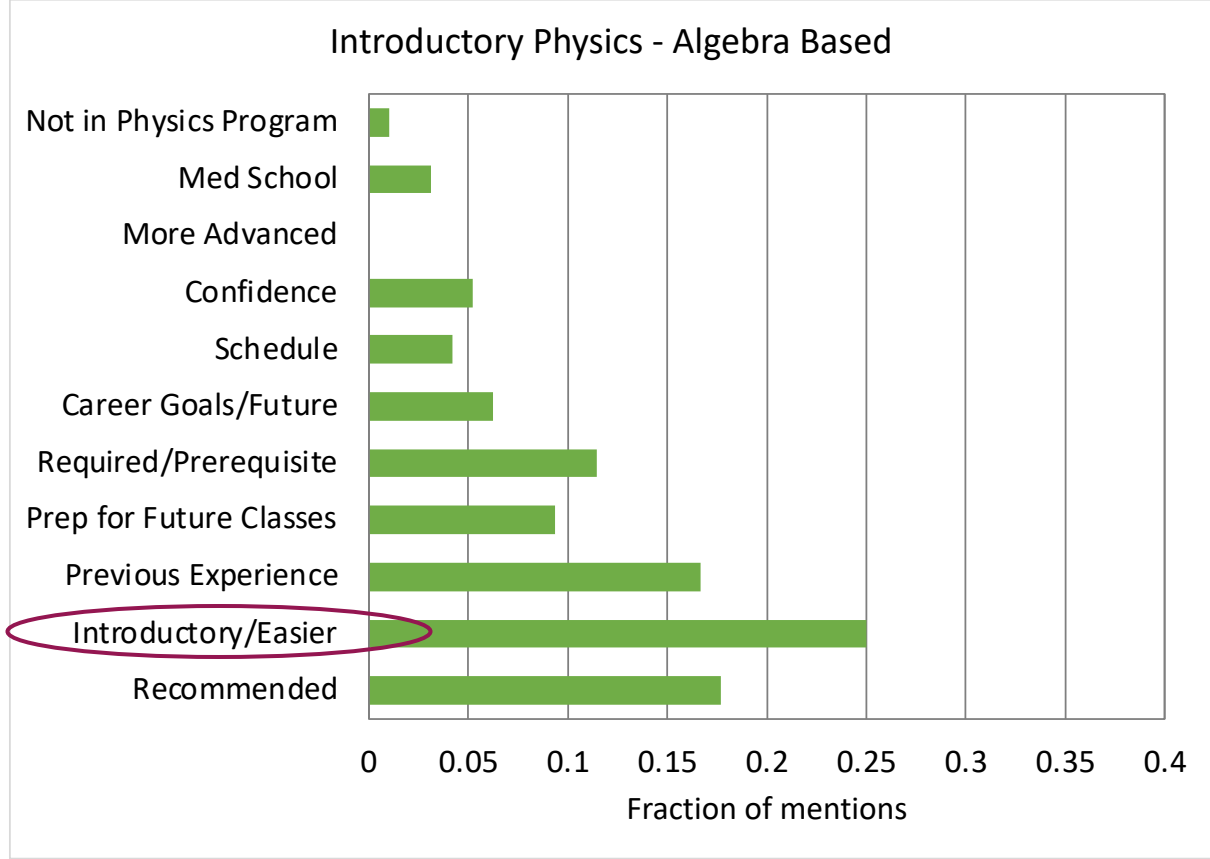
Overview: Surveys of All Introductory Physics Students

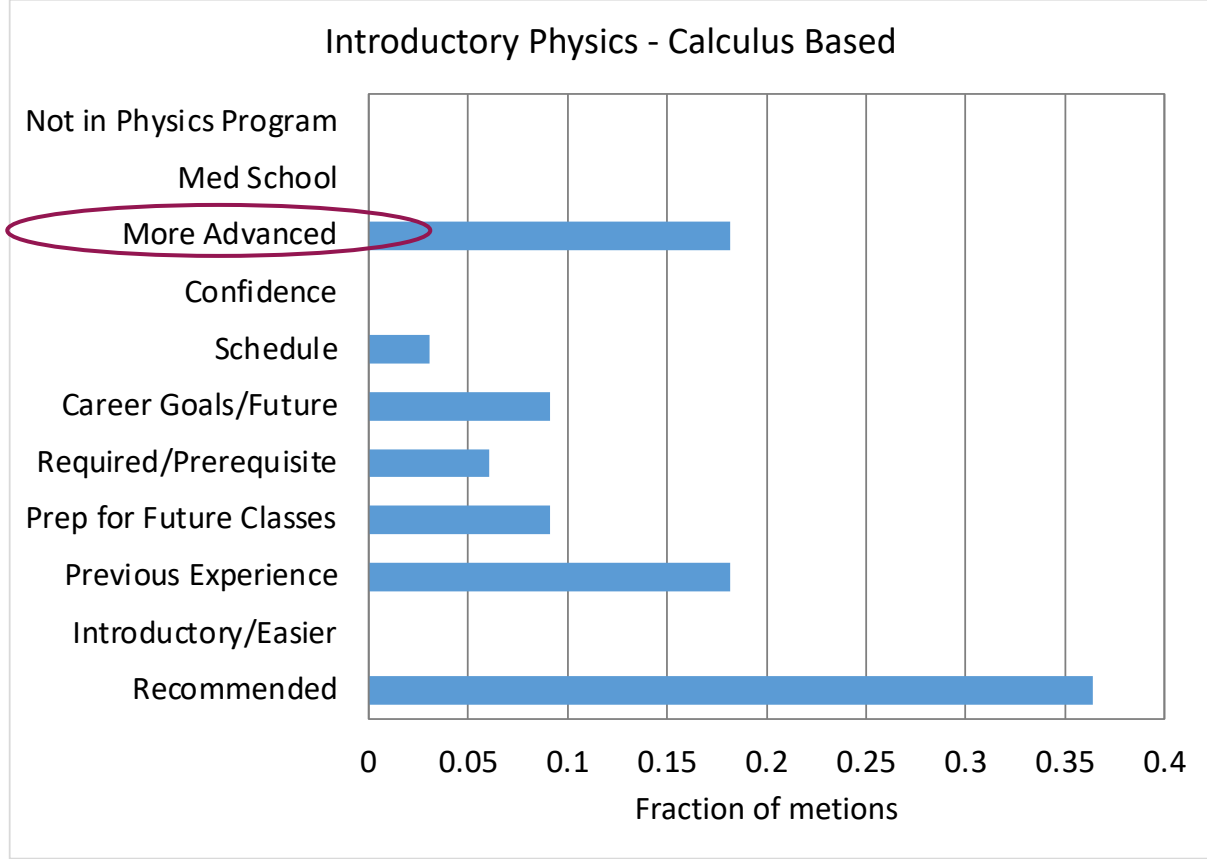
Core sections/themes:

1. Demographic information
   - Course, year, gender, program, future plans , first-generation student, Indigenous or racialized, international student
2. Preparation and Study Habits
   - Previous physics courses, choice of intro physics course, math comfort, learning strategies used
3. Motivation/Interest in Physics
   - Perception of preparedness for course, interest level in physics, favourite and most challenging physics topic, favourite and most challenging aspect of physics course, plans to take future physics courses

Study was reviewed and approved by the McMaster Research Ethics Board (MERB#5179)

Why did you choose this particular physics course?



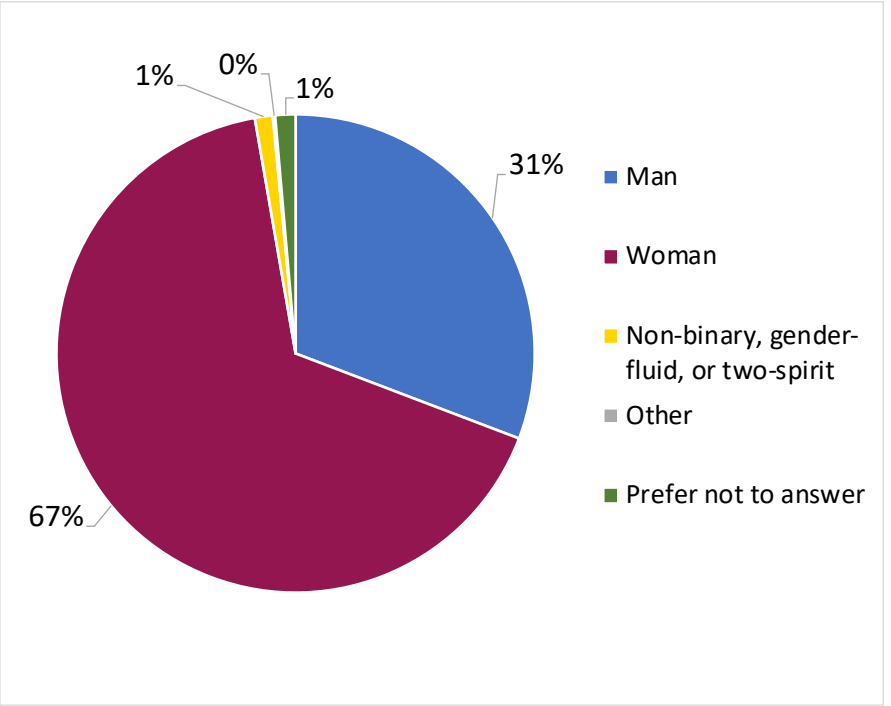


- Fraction is: # of mentions of one theme/total mentions of all themes
- Word of mouth/recommended, previous experience, and level of difficulty are the most cited factors

Who are our students in the algebra-based intro physics?

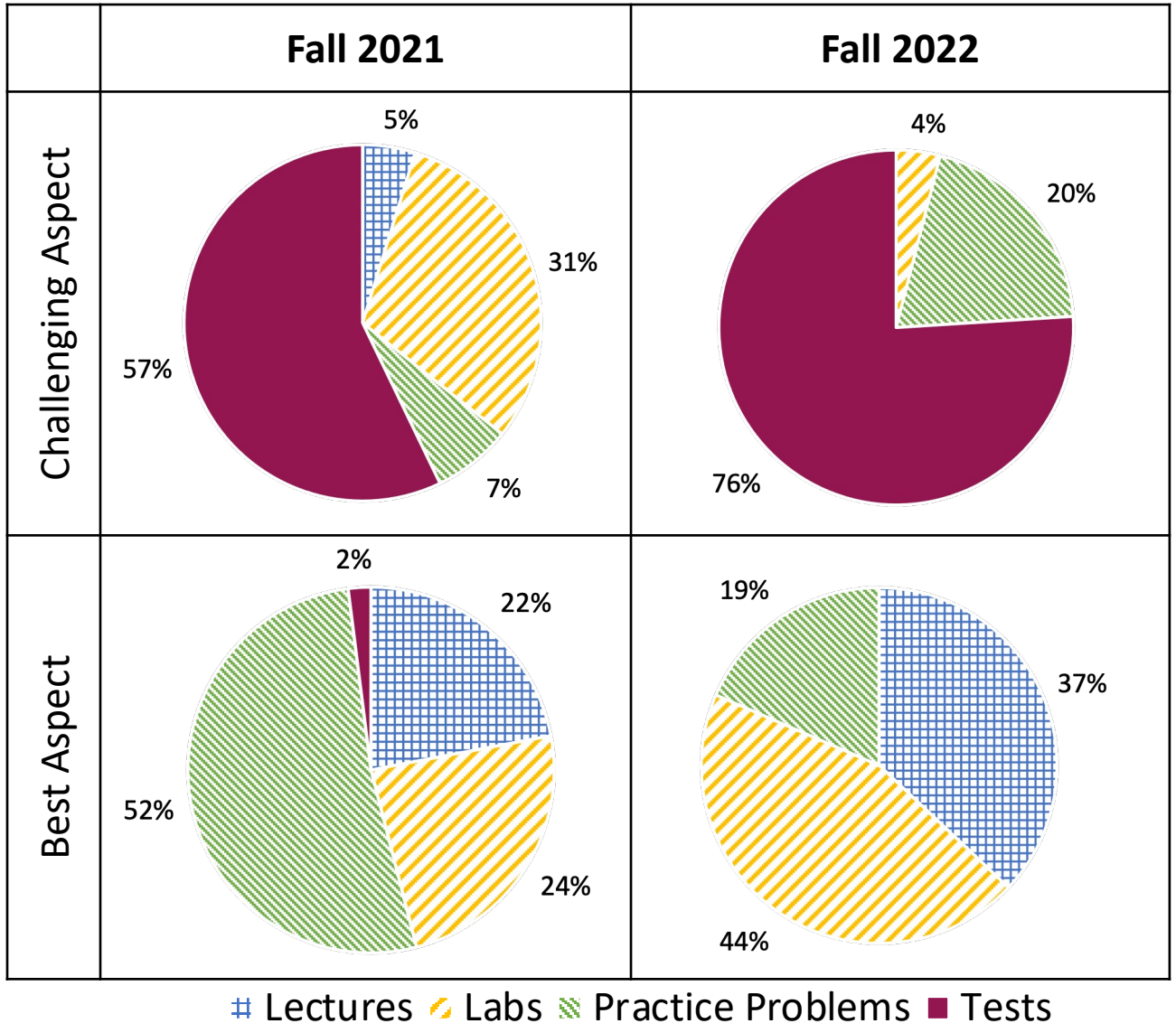
- Mainly students in Life Science Gateway (year 1)
- Some upper year students
- Mix of students with grade 10 science to grade 12 high school physics
- Many students will not continue in physics – this will be their only university physics course.
- Many students have preconceived notions, misconceptions, and fears of physics.

Our goal: provide a fun, useful course for students with a wide variety of interests and goals in science



Approximate gender distribution in 2022 – 2023 academic year based on survey responses

Which aspects of the algebra-based intro physics course do students enjoy most and find most challenging?



Course format:

- Fall 2021
  - Pre-recorded lectures
  - Synchronous problem-solving and office hours online
  - At-home labs
- Fall 2022
  - In-person and livestreamed lectures
  - Online office hours
  - Four in-person labs and one at-home lab

Comparing Lab Modalities: In-Person vs Lab Kits in our Algebra-based Introductory Physics Course

What do we want our students to get out of the labs?

Positive, enjoyable experience

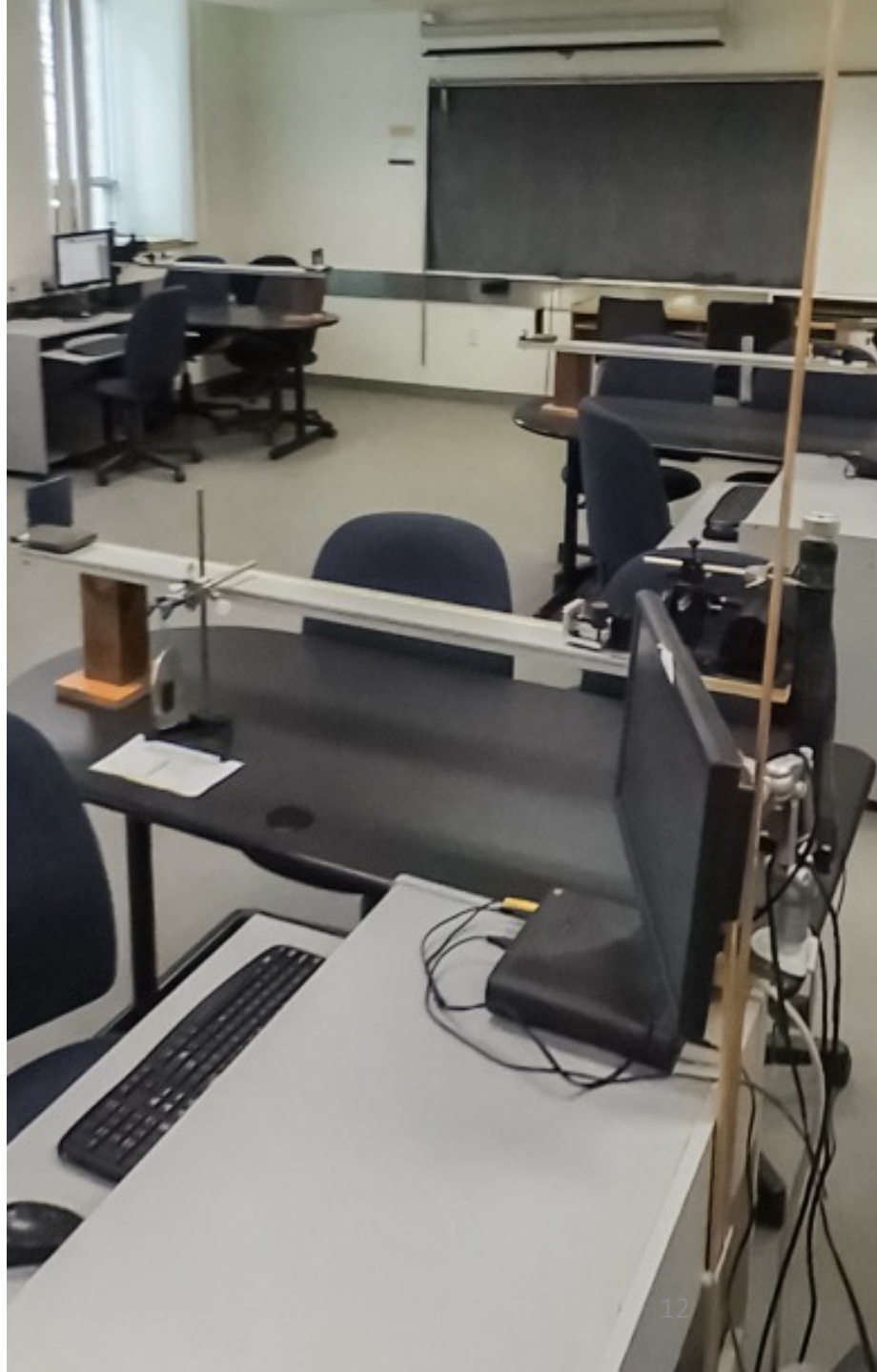
Transferrable skills: understand proportionality, the ability to create and interpret graphs (mostly linear)

Ownership of their data – no black boxes

Understanding of some physics concepts

Pre March 2020 Labs

- Participation model – no pre-labs, no lab reports
- In groups of 3
- Lab equipment set-up for students
- Students answer a set of questions and discuss with group and TAs
- Graphing software creates graphs for students from sensor data



Post March 2020 Labs

- Must be done at home
- Equipment must be affordable and easily sourced
- Equipment must be safe
- Data analysis software must be free and accessible to students

Solution → Lab Kits

Open-source lab instructions shared: https://www.diylab.ca

Mixed modes format (Fall 2022 and Winter 2023)

4 in-person labs using equipment in our traditional lab rooms

- Topics: Kinematics, Forces, Conservation of Energy, Waves
- Completed in groups of 3

1 at-home lab

- Topic: Kinematics
- Completed either individually or in groups of up to 3
- Replaces the previous video project students did

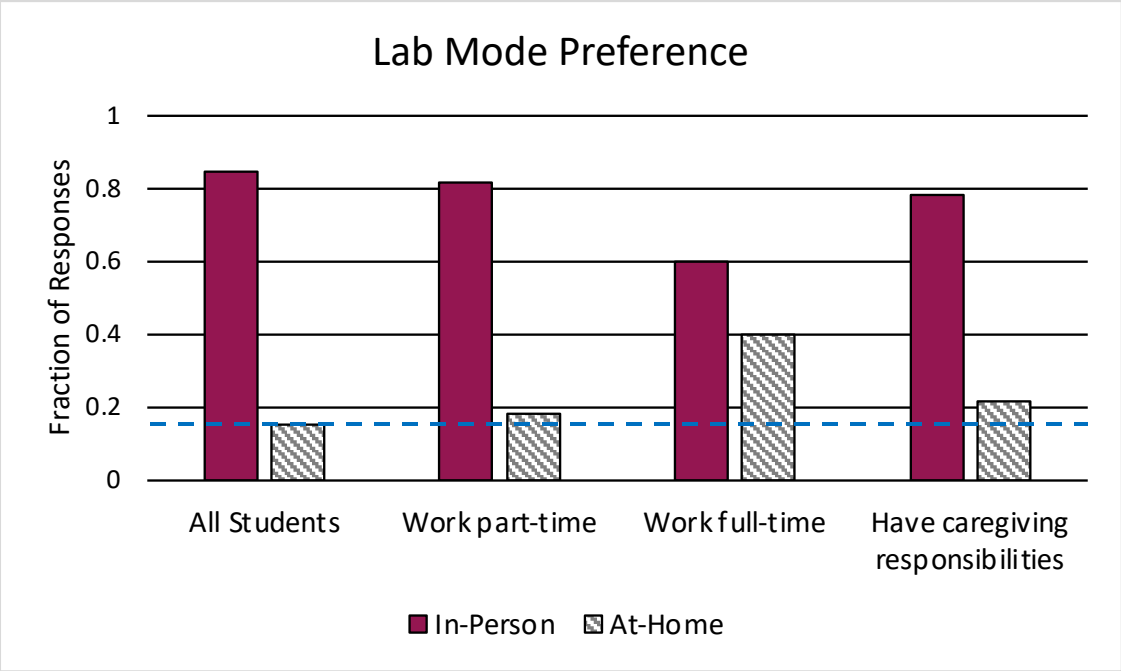
Fall 2022 and Winter 2023 Lab Survey

Three sections:

1. Questions about each kinematics lab
   - Rate enjoyment
   - Rate perceived learning of three specific outcomes/skills
   - What was the best and most challenging part of the lab
2. Which format did you prefer and why?
   - Also asked which lab was completed first
3. Demographic information
   - Gender, commuting status, work/caregiving/other responsibilities, first-generation student

Study was reviewed and approved by the McMaster Research Ethics Board (MERB#6109)

Which mode do students prefer?



- Some comments indicated that some students did not have a preference, or that they would like to have more of a mix of modes
- Students with work or caregiving responsibilities are more likely to prefer the at-home lab mode

Why in-person labs?

- Collaboration
- Professional / specialized equipment
- TA interactions / immediate feedback

Why at-home labs?

- Flexible
- Less pressure / more comfortable
- More time to work with concepts

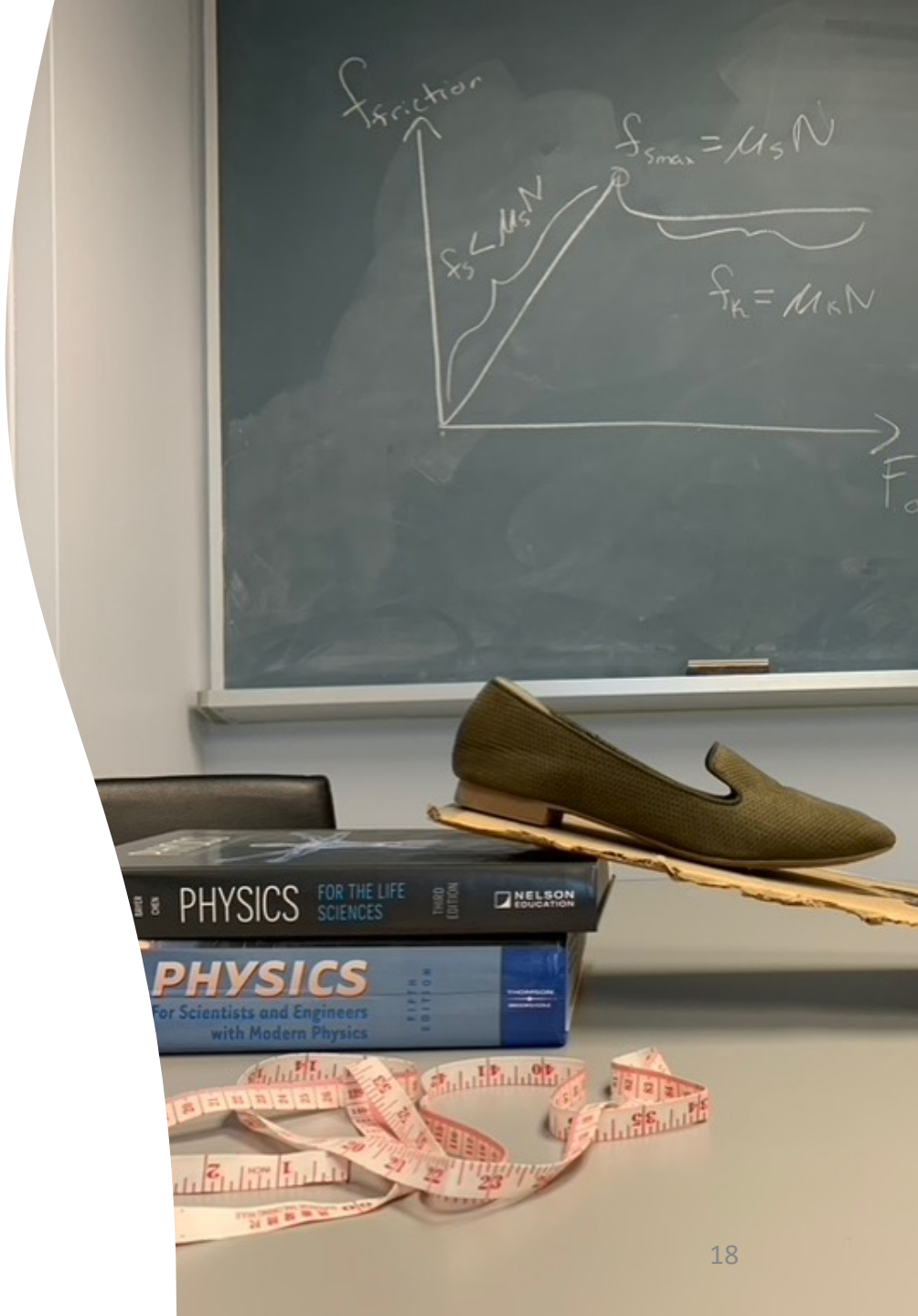
Perceived learning

Rating scale: 1 (I learned nothing about this) to 5 (I learned a lot about this)

Topic	Number of Responses	Mean Score	Standard Deviation
Understanding of kinematics concepts – in-person	1254	**3.99**	0.95
Understanding of kinematics concepts – at-home	1242	**3.52**	1.08

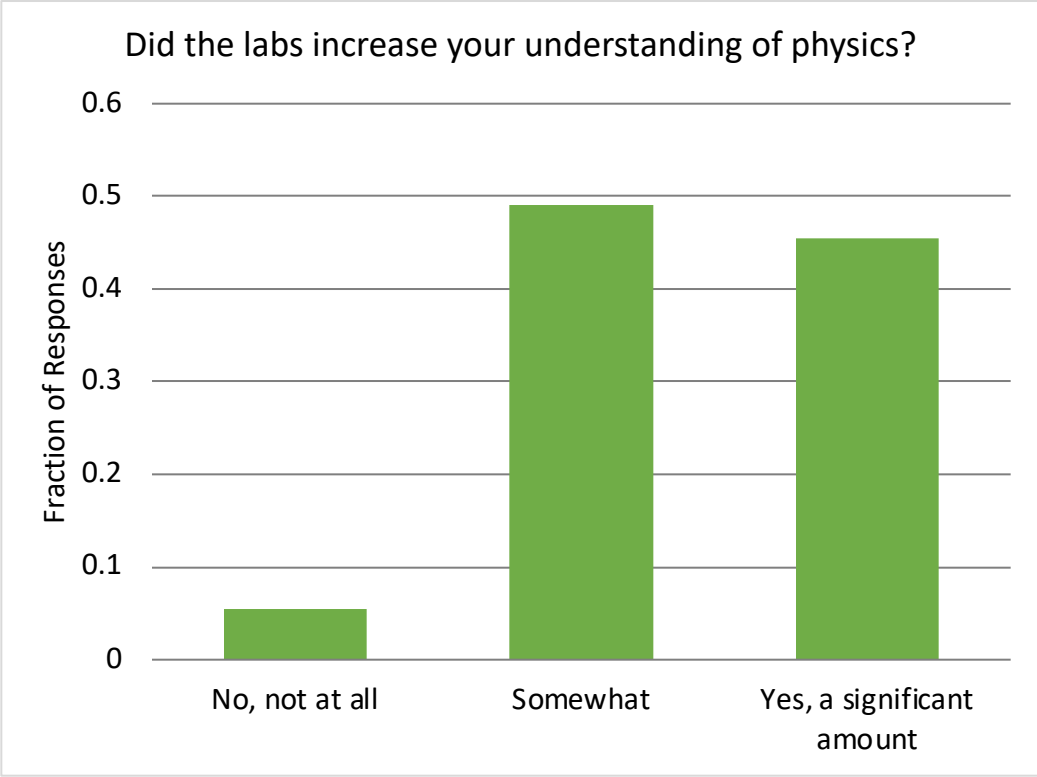
Moving forward → Hybrid lab format

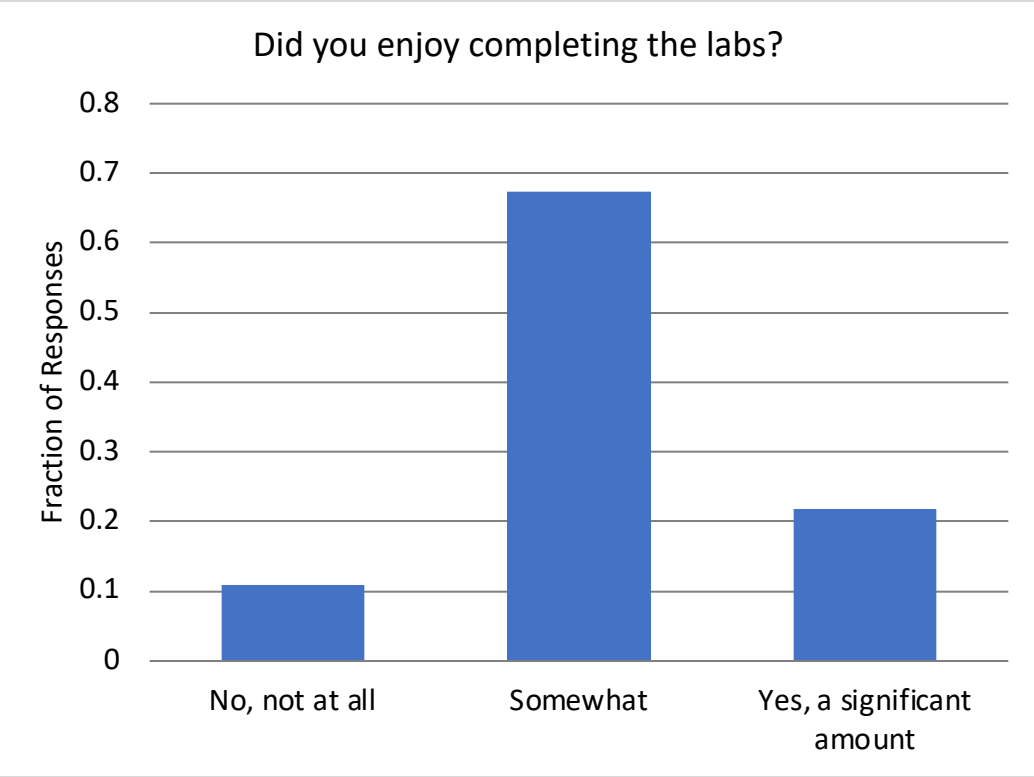
- Complete the same labs either in lab or at home
- Aligned with Universal Design for Learning – strive to make the lab as accessible as possible for all students:
  - All students feel supported with collaboration opportunities and TA support
  - Students gain transferrable skills → graphing and data analysis
  - Flexibility in how/when students complete labs
  - Incorporate opportunities for students to go to the lab in-person and play with more advanced equipment (i.e. double slit interference, standing wave generators, thin film interference setup, vacuum tubes for falling g…)



Hybrid Labs in Spring 2023 – Initial Student Feedback

- ~55 students enrolled in Spring offering
- 60% said labs took 3-4 hours to complete
- 50% attended at least one lab in-person → flexibility was appreciated





Summary

Surveys of Intro Physics Students

- Gain insight into students' decision process and a current understanding of different cohorts' experiences
- Future plan: develop a longitudinal study to
  - guide and inform future improvements to courses/curriculum
  - monitor the effectiveness of changes
  - better understand the choices students are making through their academic careers

Hybrid Labs

- Flexibility and support built in
- Students have ownership of their data and develop transferrable skills
- Initial feedback from students on this format from Spring 2023 is positive
- Currently working with a student to make updates to the labs and move them to a more accessible and interactive format in PressBooks ahead of the Fall offering

Questions?