

Background

- Students have a gap in their understanding of the application of math in physics
- Novice** students **perform better** on multiple-choice, calculus-based introductory mechanics problems that use **numbers** than on those that use symbols [Torigoe & Gladding, 2011]

Methods

PHYS 2211: Principles of Physics 1

Calculus-based introductory mechanics
Fall 2024 – **970/1215** consenting students
Spring 2025 – **1116/1275** consenting students

A/B Testing with 4 exams across 2 semesters

Version A:	Version B:
Problem <i>i</i> : symbolic	Problem <i>i</i> : numeric
Problem <i>j</i> : numeric	Problem <i>j</i> : symbolic

Problems of similar difficulty and same total point value

Students randomly assigned exam versions

Exams are fair: Mann-Whitney *U* tests do not detect statistically significant differences between versions for any exam

Results

- By problem:** 4/8 with significant difference between numeric and symbolic (numeric higher)
- By subparts:** 10/25 with significant differences (numeric higher)
 - 4 control subparts showed no difference (e.g., free body diagram)
 - Propagation of error (**POE**) is possible in 13/25 subparts

Course Standing	Lower 25%	Middle 50%	Upper 25%	All
Normalized difference of means averaged over subparts	12% ± 2%	8% ± 1%	3% ± 1%	8% ± 1%
# subparts for which omitting POE causes $p > 0.05 \rightarrow p < 0.05$	4/13	4/13	3/13	1/13
# subparts for which omitting POE causes $p < 0.05 \rightarrow p > 0.05$	0/13	1/13	2/13	1/13

Removing POE appears to change statistical significance in different ways depending on students' course standing

Limitations & future work

- Possible lack of generalizability:** only STEM majors, prior knowledge from high school physics, repeated topics in final exams, different instructional styles
- We need to further investigate **effects of POE**
- Interviews with course instructors** will help us understand the strategies used in teaching problem-solving
- Student surveys** (plus interviews?) needed to explore how students approach problem-solving

The average student **scores 7–9% lower** on symbolic problems than on numeric problems in exams.

