Can Students Solve for x: Introductory Physics Students' Approaches to Problem Solving

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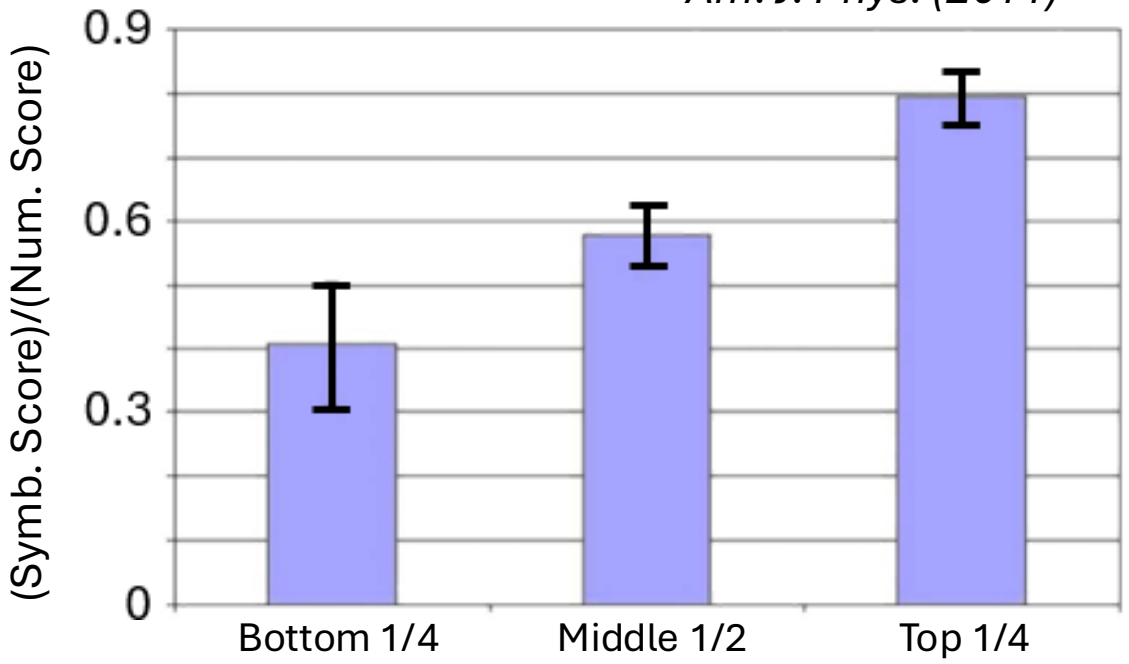
Students have a gap in their understanding of the application of math in physics.

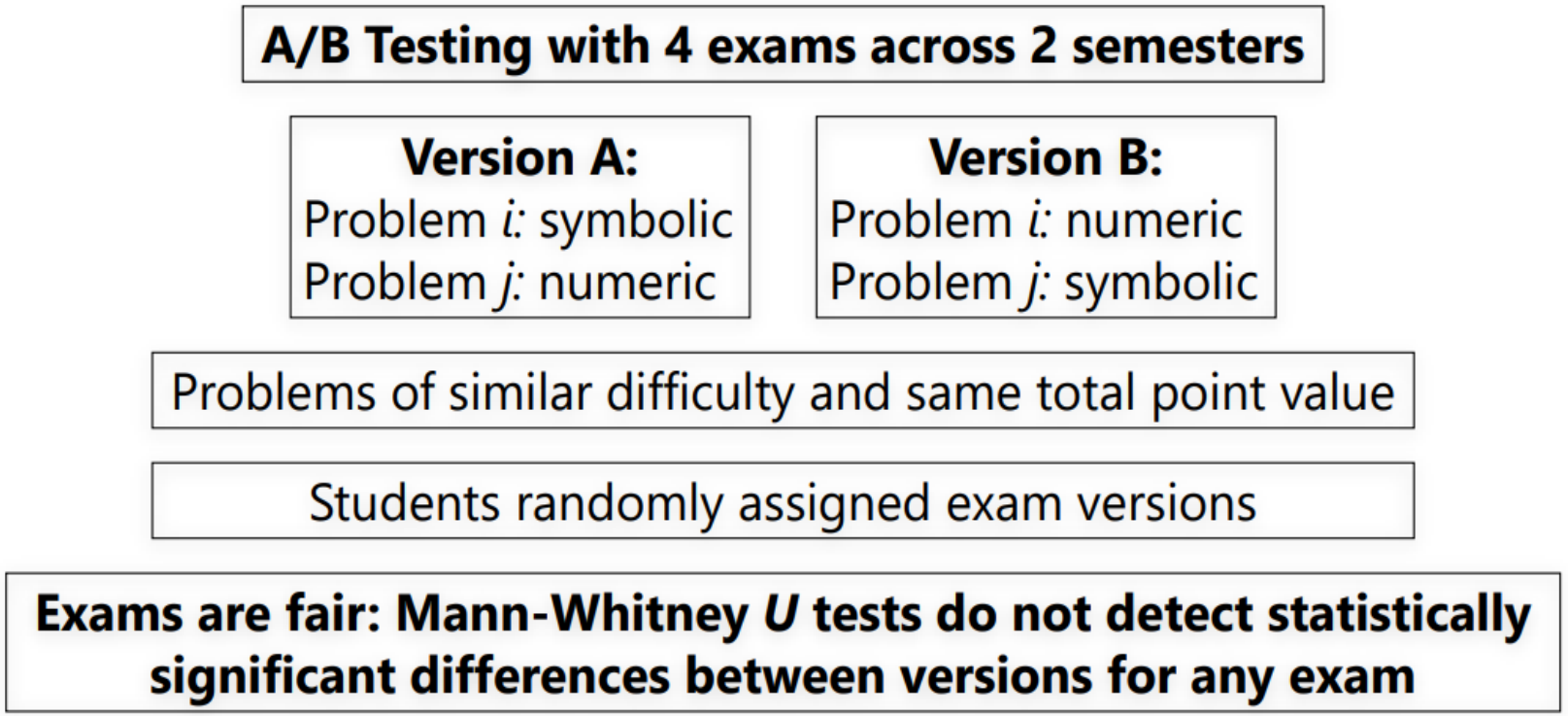
- Math is the language of physics – students must properly understand and apply math to "do" physics
- Torigoe and Gladding (2011)
  - Study done using multiple-choice calculus-based physics questions.
  - Students showed **higher proficiency** in solving **numeric** problems **over symbolic** problems.
  - These results were especially pronounced in lower 25% of class.

Torigoe & Gladding, *Am. J. Phys. (2011)*



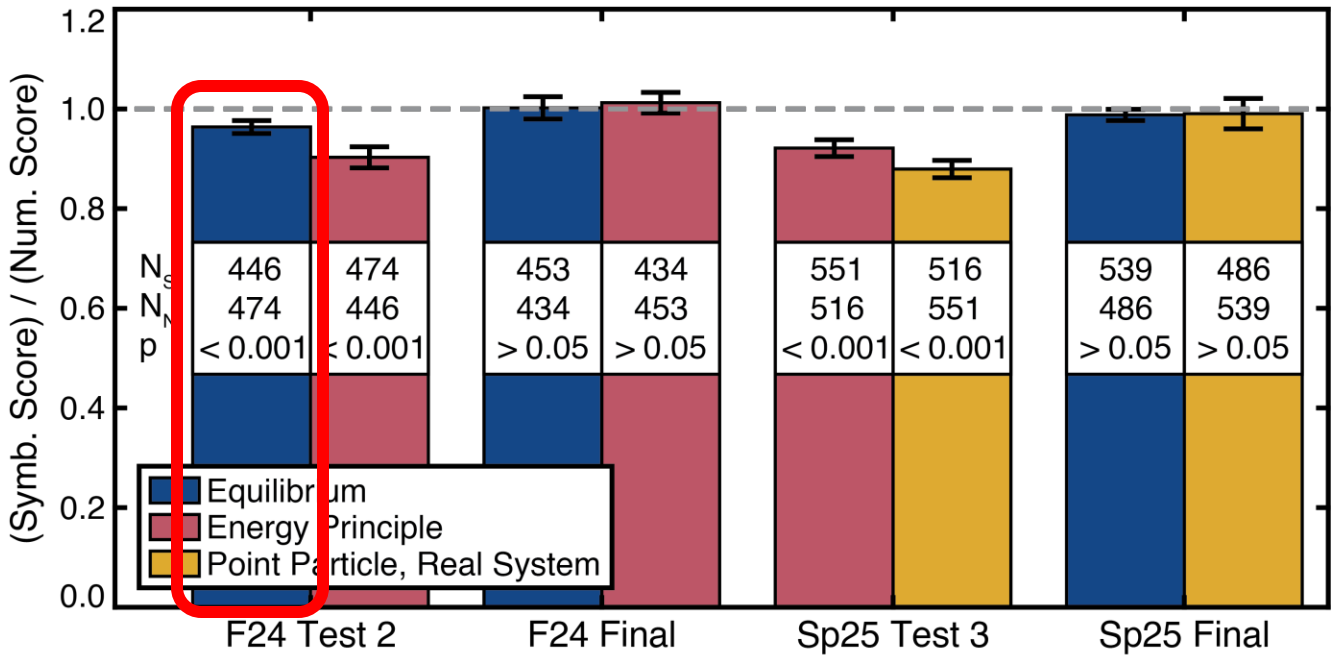
Does this trend also arise when students are given open-ended, multiple-part questions?

- **A/B testing** in two semesters of PHYS 2211: Principles of Physics 1 (calculus-based introductory mechanics)
  - **970/1215** (80%) consenting students in Fall 2024
  - **1116/1275** (88%) consenting students in Spring 2025



Initial results show that students either scored lower on symbolic problems or there was no difference between representations.

- **4/8** of problems showed a **significant difference** between representations
  - **Final exams** did **not** show detectable differences
- **10/25** subparts showed a **significant difference** in scores between numeric and symbolic representations
  - 4 subparts (e.g., free body diagrams) showed no detectable difference between representations



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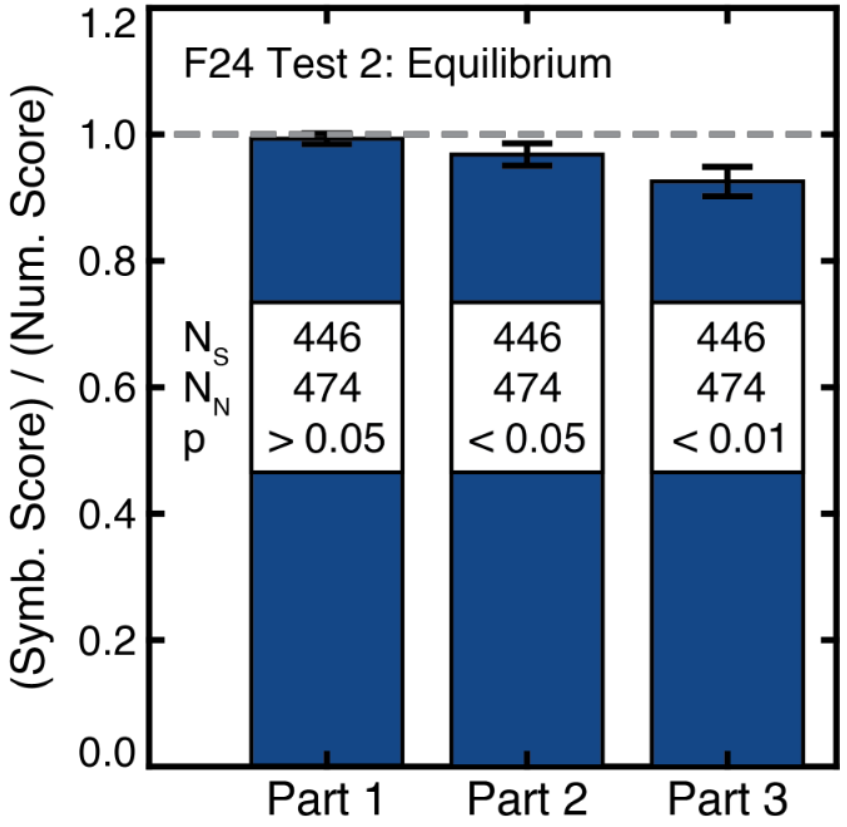
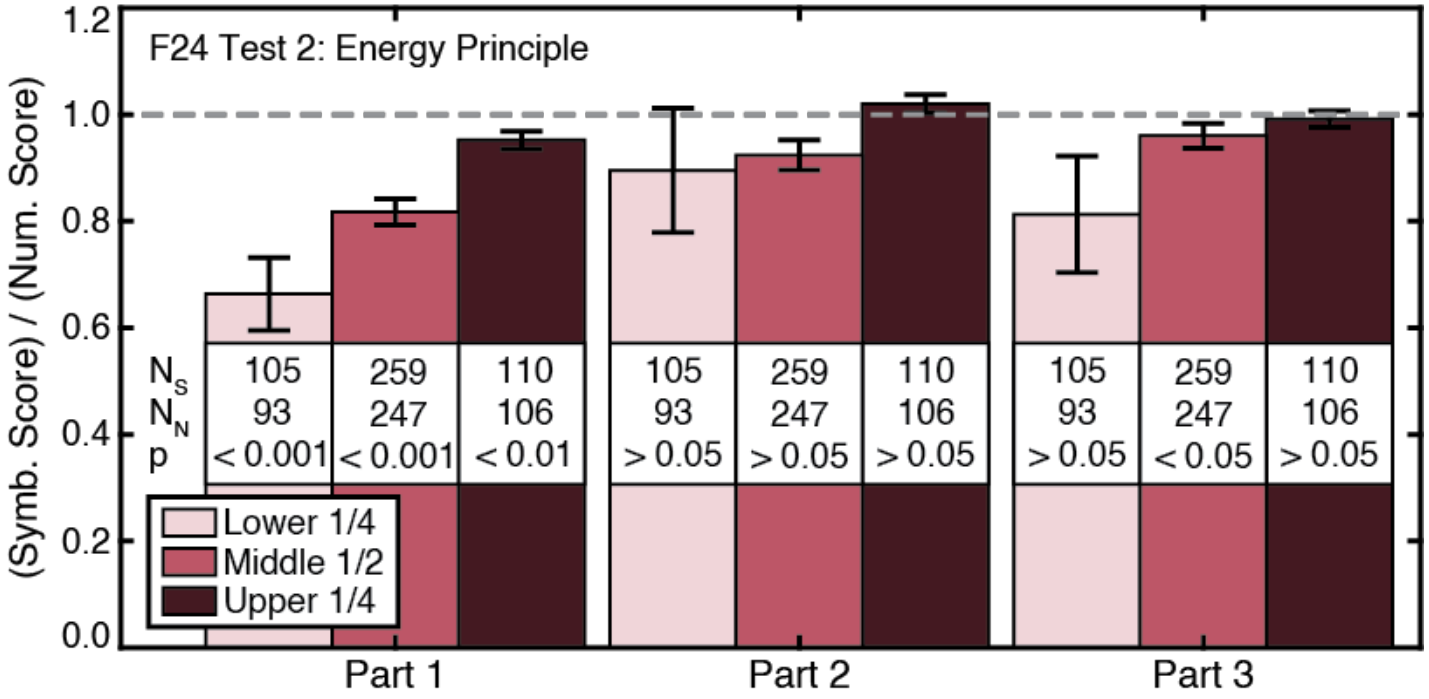


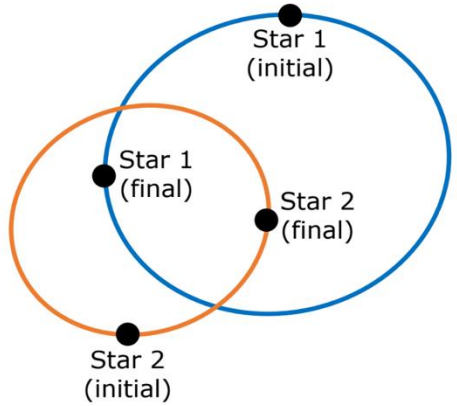
Students' overall standing in the course suggest trends of mathematical understanding.

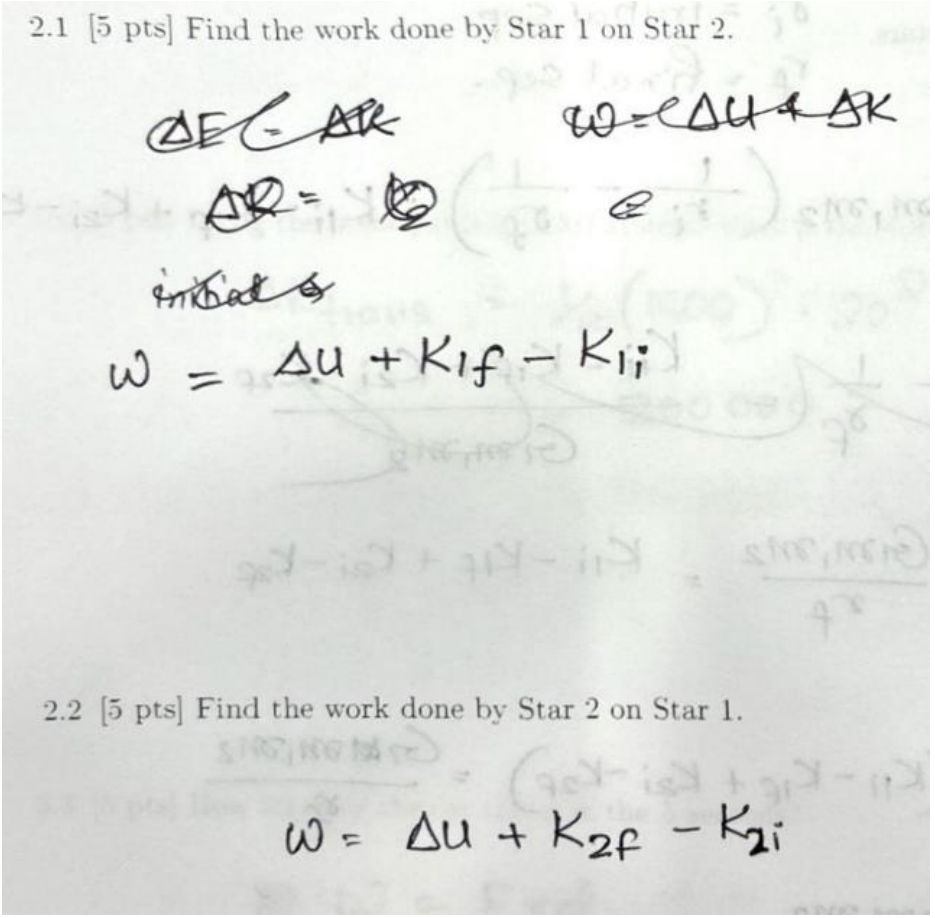
- Students with **lower course standing** often scored **better on numeric** problems than symbolic problems.
  - Their score can be affected by **12% ± 2%** of the problems' point total.
- Students with **higher course standing** scored **similarly** on numeric and symbolic problems.
  - **3% ± 1%** of the problems' point total.
- Regardless of course standing, students performed the same on control and final exam questions.



Propagation of error (POE) seems to **influence** significance of results.

- Hypothesis: POE may show understanding of the subpart in context of the question rather than physics.
  - **13/25** subparts had the option to get full points due to POE.
  - In one question, 40% of students got full credit because of POE.
- Removed students who received POE credit from dataset and recalculated statistics
  - One comparison **became significant**, while another **became unable to detect a significant difference**.





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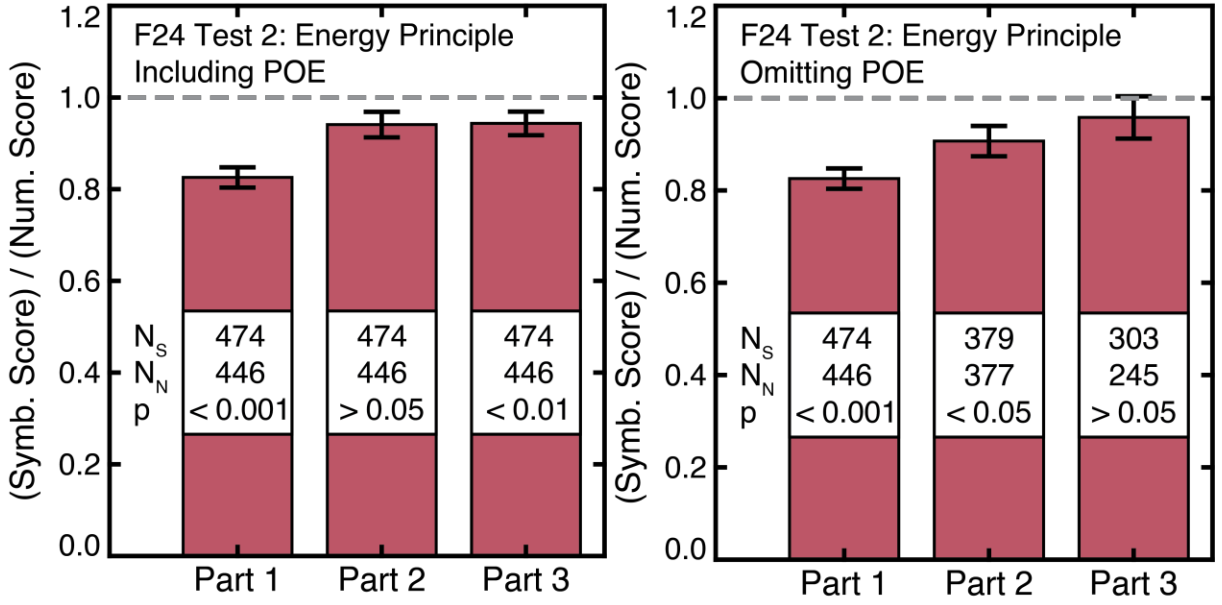

The use of symbols or numbers can impact students' exam scores in calculus-based introductory mechanics.

- Students tend to **score lower on symbolic questions** over numeric questions.
  - The average student's score can be impacted by **7–9%** of problems' point total.
  - Final exams appear to be exceptions.
- Students with **lower course standing** seem to **struggle more with symbolic** problems than with numeric problems.
- Future work:
  - Further investigate the effects of POE
  - Interview professors to explore how problem-solving is taught
  - Survey (and interview?) students to explore how they approach problem-solving

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@ Wednesday 7:30 - 8:10