

It's not you. It's the numbers.

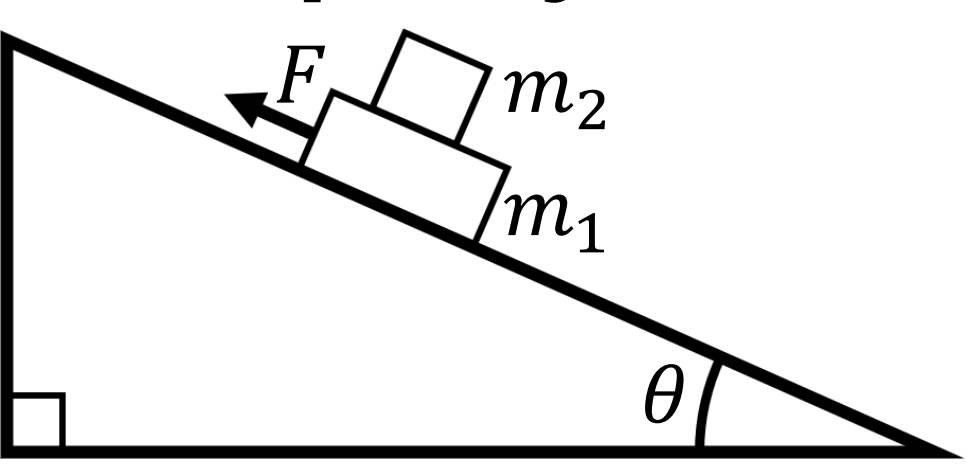
"I generally hate numbers.": Translating Instructor Attitudes about Problem-solving Representations to Student Performance in Introductory Mechanics

Background: Novice physics students regularly **struggle with symbols significantly more than with numbers**.

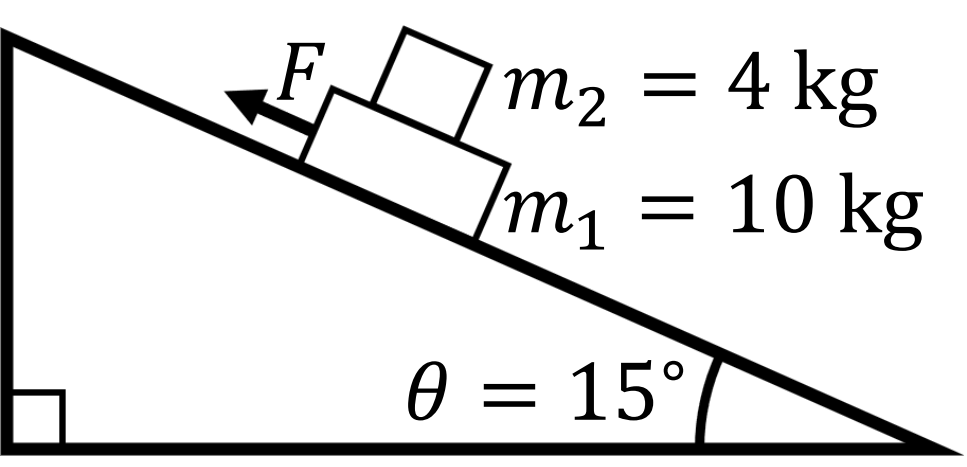
Cognitive modeling and student interviews suggest pattern recognition as a cause [Tuminaro & Redish, 2007; Torigoe, 2015].

We manually reviewed 875 exams and **coded student strategies** not in the original grading rubric for two multipart problems.

Example Symbolic



Example Numeric



Example Coded Solutions

[Symbolic]

$$F_{net}^{\perp} = 0$$

$$\Rightarrow N_1 - m_2 g \cos \theta = 0$$

$$\Rightarrow N_1 = m_2 g \cos \theta$$

Plug in here for...

[Novice-like]

[Intermediate]

[Numeric]

$$F_{net}^{\parallel} = 0$$

$$\Rightarrow m_2 g \sin \theta - \mu_k N_1 = 0$$

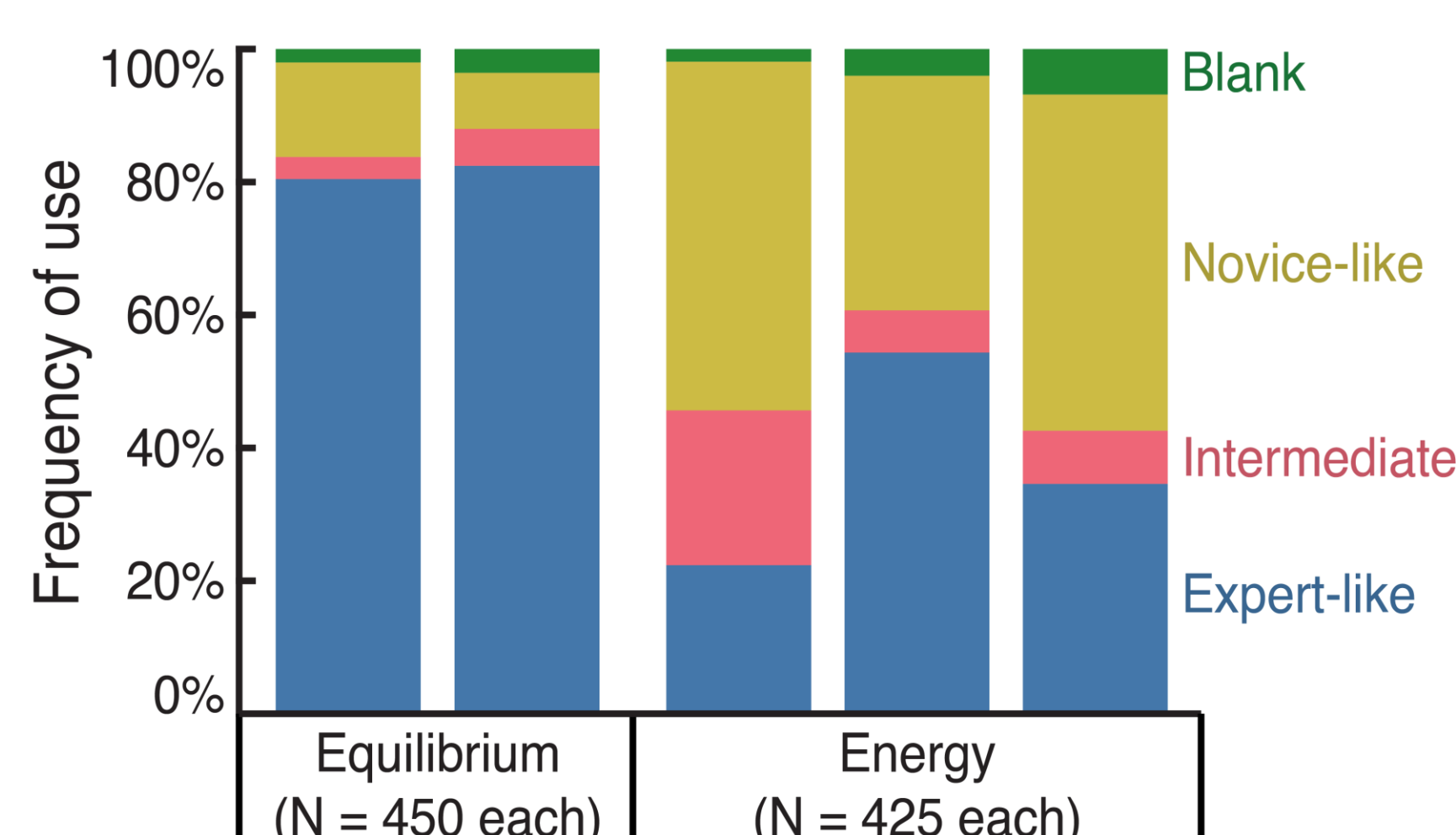
$$\Rightarrow m_2 g \sin \theta - \mu_k m_2 g \cos \theta = 0$$

$$\Rightarrow \mu_k = \frac{\sin \theta}{\cos \theta} = \tan \theta$$

[Novice-like]

[Expert-like]

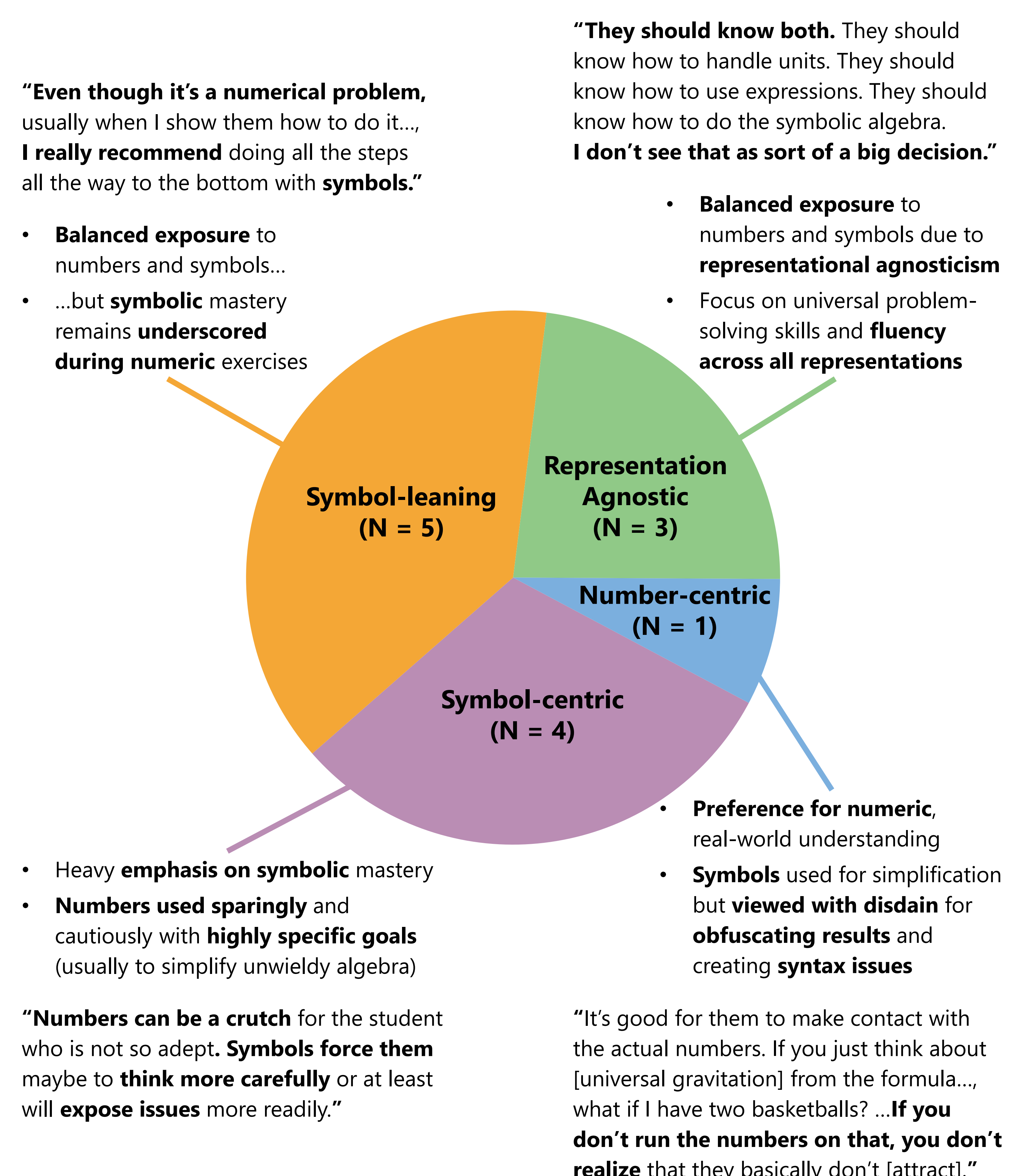
Students engaged in **novice-like** behaviors on numeric exam problems **far less than anecdotal evidence suggested**.



The presence of numbers alone appears sufficient for slightly but significantly **higher exam performance** in introductory mechanics.

Symbolic never wins!	Pairwise score comparison (adjusted Mann-Whitney U test, showing only significant pairs)	How many of 5 parts?	Effect size (Cliff's $\delta \pm SE$)
	Expert-like > Symbolic	3	0.09 ± 0.02
	Intermediate > Symbolic	1	0.08 ± 0.01
	Novice-like > Symbolic	1	0.12 ± 0.02
	Expert-like > Novice-like	1	0.03 ± 0.01
	Intermediate > Expert-like	1	0.011 ± 0.004

Interviewed **instructors** consistently recognized student difficulties with representations but **disagreed** on how best to address them.



Instructors’ pedagogical **philosophies** often **did not correlate** with student **strategy usage or score** in either representation.

Limitation: We analyzed two multipart problems on distinct topics, both of which were only on the second exam of four that semester. Future works should assess **reproducibility** and the **impacts of student growth** throughout the semester.