

# Students' Ideas of Force-Distance Tradeoff in an Inclined Plane

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# CoMPASS Curriculum

- CoMPASS<sup>1</sup>
  - Design- & project-based
  - Interactive hypertext
    - Concept maps & textual descriptions
- Simple Machines
  - Conceptual understanding
    - Force, work, force-distance tradeoff
  - Our focus: Inclined planes

The screenshot shows a web browser window displaying the CoMPASS website. The page title is "friction in Inclined Plane". The content includes a definition of friction and a concept map. The concept map shows the following relationships:

- efficiency is reduced by friction.
- friction is a type of force.
- force affects mass (m) and gravity (g).
- efficiency depends on force.
- work is affected by efficiency.

The text on the page explains that friction is a force that resists motion, making work seem harder. It discusses how friction is affected by the surface of the inclined plane and how wheels can reduce friction by rolling instead of sliding.

<sup>1</sup>S. Puntambekar and A. Stylianou , 2005

# Research Context

- 85 participants
  - Conceptual physics: elementary education majors
  - 93% female
  - 92% between ages of 18 and 22
- Interview Protocol
  - Inclined planes pre-test & anticipation guide
  - Brainstorming & predictions of length and surface
  - CoMPASS hypertext system
  - Hands-on activities
  - Open-ended summary questions & post-test
- Data sources
  - Videos of activities
  - Worksheets

# Research Questions

- What factors influence students' predictions about the length & surface of an inclined plane that would best complete their challenge?
- To what extent did students' knowledge of inclined planes improve after using the CoMPASS curriculum?

# Students' Predictions

**Length and surface** of board to best complete the challenge:

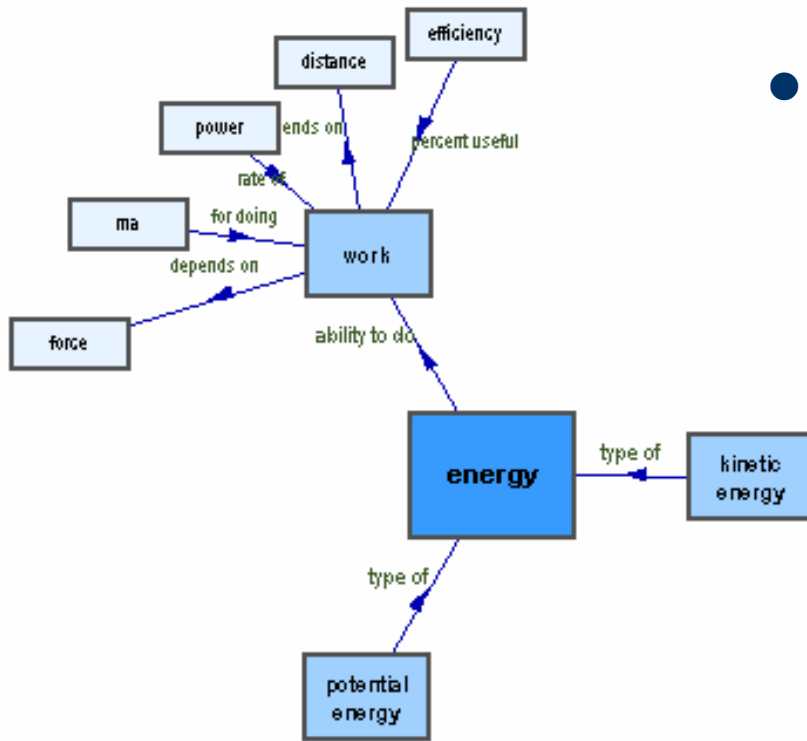
- Use of **everyday physical reasoning**

- “The length of the board I will need has to be bigger and wider than the pool table. This will allow me to have enough space and balance to carry/pull the table.”
- “Make sure wood is thick enough so it won't snap.”

- Consistent with of **physics principles**

- “You will want a board with a little friction because you don't want the pool table to slide easily (if it were to slide backwards).”
- “Surface with some kind of friction so you won't slide on the smooth surface.”

# Inclined Plane Activities



- CoMPASS hypertext system
  - Students chose concepts to click on map.
  - Possible concepts: force, work, energy, mechanical advantage etc.




- Hands-on Activities

- Same surface, different lengths.
- Same length, different surfaces.



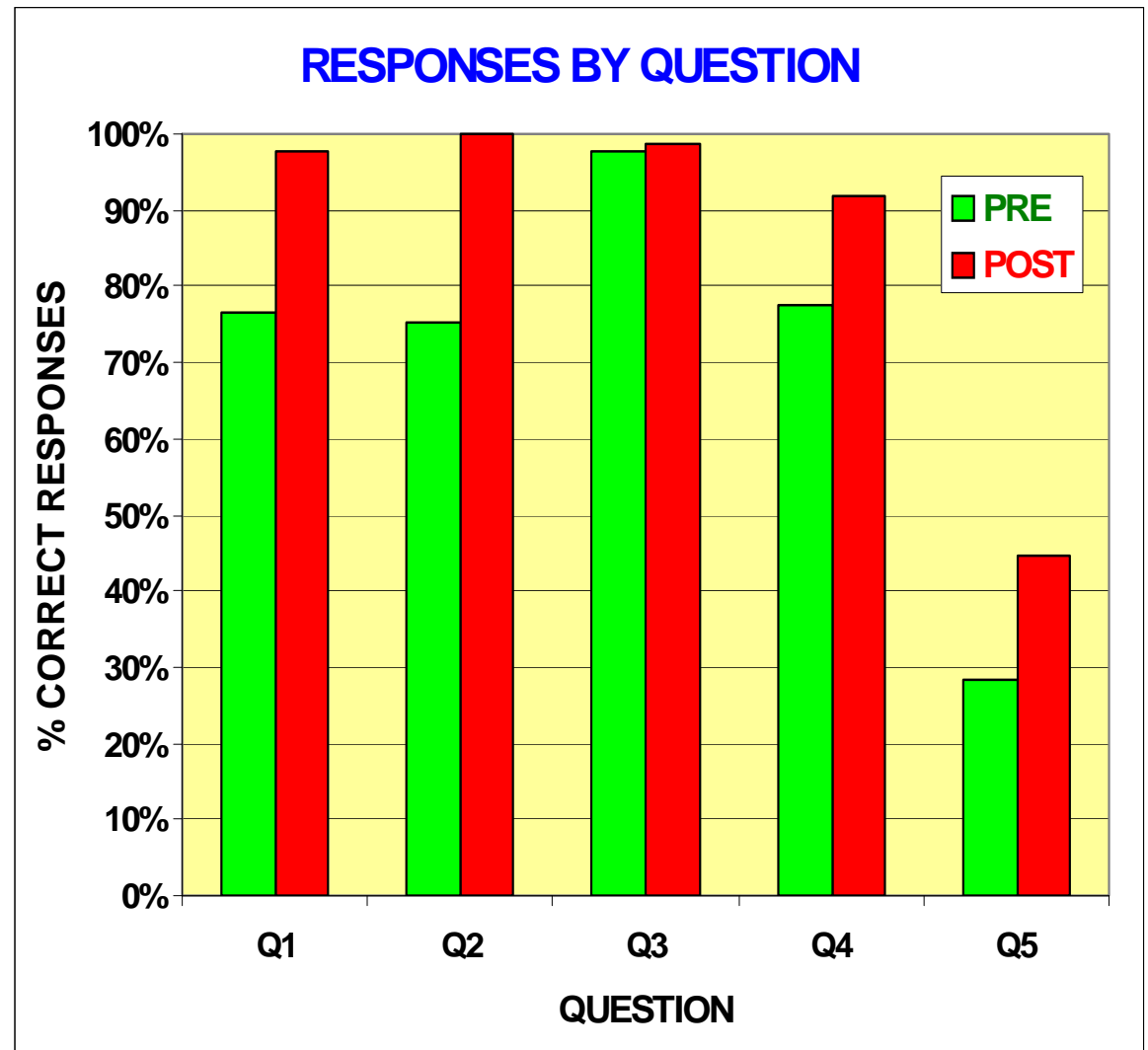
# Pre / Post-Test

Which takes the least effort force (applied force)....

Q#	Situations Compared	Figures
1	Two ramps with same vertical height, different distance up ramp	
2	Ramp vs. Lifting	
3	Two ramps with same distance up ramp, but different vertical height	
4	With friction vs. Without friction	
5	Two ramps with different vertical heights and distance up the ramp, but with same steepness	

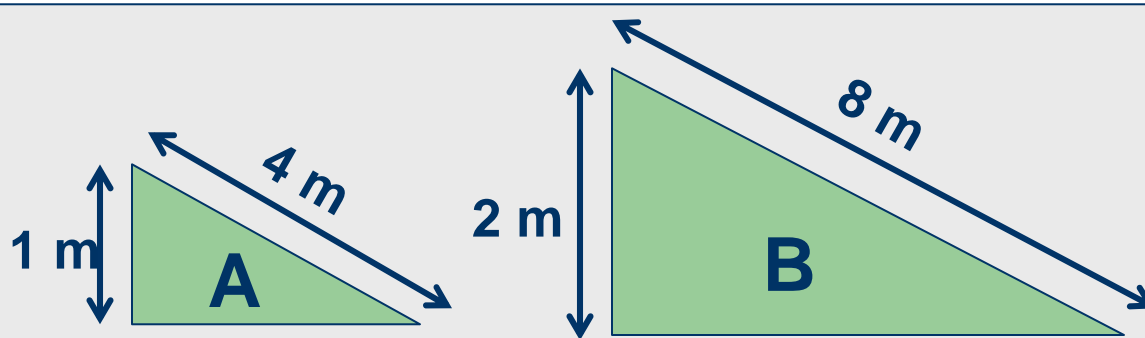
# Pre / Post-Test Results

- Pre-test mean : 3.5/5
- Post-test mean: 4.3/5
- Two-tailed t-test:  
 $p \leq 4 \times 10^{-8}$ .
- Q5: Worst scores





## Question 5



Which ramp will require the least effort force?


C: Both equal

D: Not enough information

- Only 45% got question 5 correct on post-test
- 40% of students chose Ramp A
- Students appeared to..
  - have difficulty relating **effort force** and **steepness**.
  - focus on **length** or **height** individually, not together.

# Conclusions

- What factors influence students' predictions about the length & surface of an inclined plane that would best complete their challenge?
  - Evidence of everyday physical reasoning.
  - Some ideas consistent with physics principles.
- To what extent did students' knowledge of inclined planes improve after using the CoMPASS curriculum?
  - Evidence of improvement in understanding...
    - that ramps require less effort force than lifting.
    - how ramp height, length, and friction affect effort.
  - Lack understanding that steepness is key factor.



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