Students’ Ideas of Force-Distance Tradeoff in an Inclined Plane

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CoMPASS Curriculum

- CoMPASS\(^1\)
  - Design- & project-based
  - Interactive hypertext
    - Concept maps & textual descriptions

- Simple Machines
  - Conceptual understanding
    - Force, work, force-distance tradeoff
  - Our focus: Inclined planes

\(^1\)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 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)….

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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?

A: 4 m 1 m  
B: 8 m 2 m

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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