Can Simulations Replace Hands-on in Mechanics Too?

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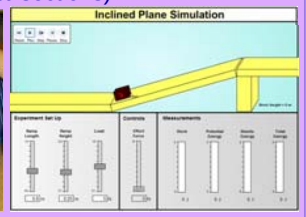
1. Introduction

- Finkelstein, *et. al.* (2005) showed that students who built virtual circuits outperformed students who built physical circuits.
- Microscopic phenomena such as current flow can be modeled more clearly in a simulation.
- We ask: Does this extend to mechanics as well?

2. Inclined Plane Study

- CoMPASS curriculum (Puntambekar, *et. al,* 2003)
- Students did activities as shown in table below.
- Students used manipulatives as shown below:
  - Physical (3 lab sections)
  - Virtual (2 lab sections)



Manipulatives	Variables Changed	N
Physical	Length & Height	29
Virtual	Length & Height	37
Physical	Length & Friction	54
Virtual	Length & Friction	30

3. Pre- & Post-Test Results

- Mean score on 16 multiple-choice questions
- Length & Height (LH) Physical & LH Virtual are statistically the same on pre-test (p=.9878)
- LH Virtual is statistically significantly higher on the post-test than LH Physical (p=.0008).

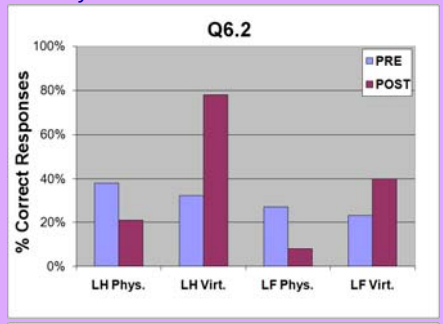
Section	Treatment	Pre-Test	Post-Test
1	**LH Physical**	**59.9%**	**66.2%**
2	**LH Virtual**	**60.0%**	**77.5%**
3	LF Physical	59.2%	66.0%
4	LF Physical	60.1%	65.9%
5	LF Virtual	56.7%	67.1%

4. What Questions on Test Led to This Difference?

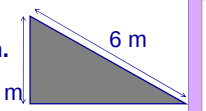
Four questions had 20% or more difference between LH Physical and LH Virtual treatments

Q6.2) You use a 5 m long frictionless ramp to move an object into a van. If you use a 10 m long frictionless ramp instead, then the *work* done would:

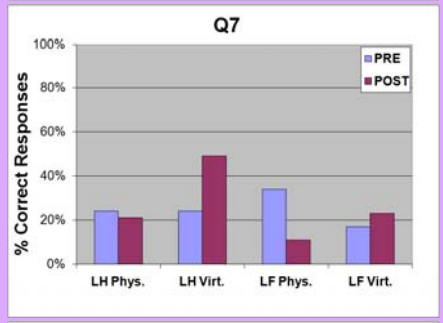
Answers	LH Phys.	LH Virt.
A. Increase	55%	11%
B. Decrease	24%	11%
C. Stay the same	**21%**	**78%**
D. Not enough info	0%	0%



Q7) Jane lifts a box straight up 2 meters. Mary uses ramp shown. If friction is not a factor, how does *work done* compare?

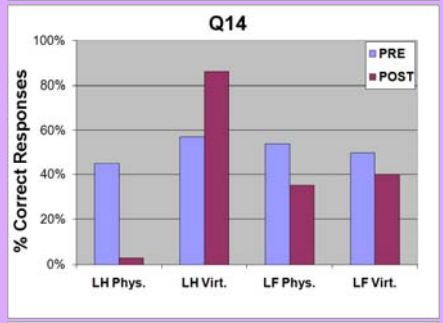


Answers	LH Phys.	LH Virt.
A. Jane does more work	38%	49%
B. Mary does more work	38%	3%
C Both do same work	**21%**	**49%**
D. Not enough info	3%	0%



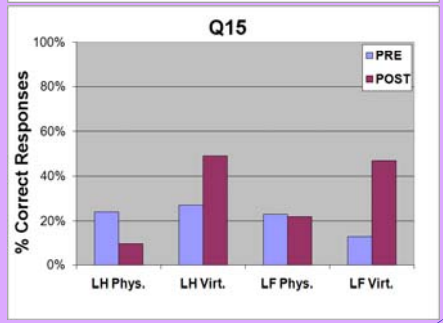
Q14) An object sits at the top of a frictionless ramp. How does the object's potential energy (PE) compare to the work required to move it to the top of the ramp?

Answers	LH Phys.	LH Virt.
A. PE > Work	28%	8%
B. PE < Work	69%	0%
C. PE = Work	**3%**	**86%**
D. Not enough info	0%	5%



Q15) How does an inclined plane's actual mechanical advantage (MA) compare to its ideal mechanical advantage (MA)?

Answers	LH Phys.	LH Virt.
A. Ideal MA always > Actual MA	48%	22%
B. Ideal MA always < Actual MA	14%	8%
C. Ideal MA = or < Actual MA	10%	22%
D. Ideal MA = or > Actual MA	**28%**	**49%**



5. Discussion

- LH Virtual students perform best overall.
- In Q6.2, 7 & 15 only virtual students improve.
- In Q6.2 frictionless ramp causes difficulty for LH Physical but not LH Virtual students, because latter have only seen frictionless case.
- The difference in friction's presence could also explain the difference in Q14 and Q15.
- Q7 seems to be difficult for all students. Absence of friction does not explain results.

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