

# Effectiveness of Hands-on Experiments versus Computer Simulations in Mechanics

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# Research Questions

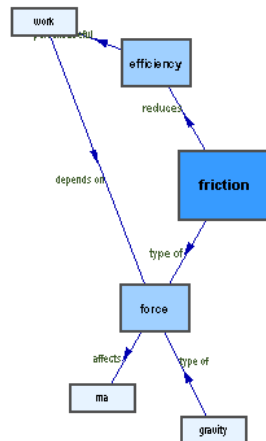
- Is there a difference in conceptual understanding between students who perform an experiment physically or virtually in the context of mechanics?
- What particular concepts are most influenced by physical vs. virtual?

# CoMPASS Curriculum

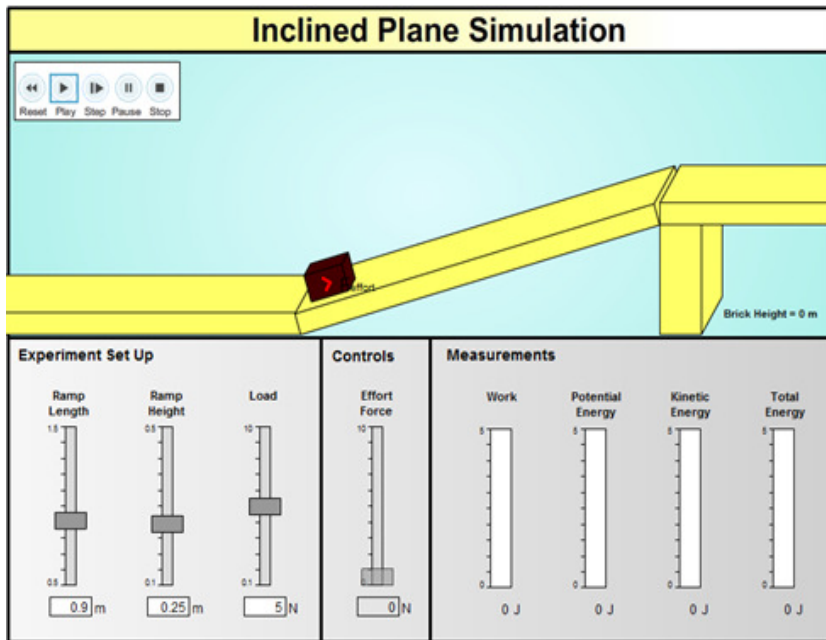
- CoMPASS = Concept Map Project-based Activity Scaffolding System
- Brings together dynamic concept maps and text, designed-based challenges and physical and virtual inquiry activities.

## friction in Inclined Plane

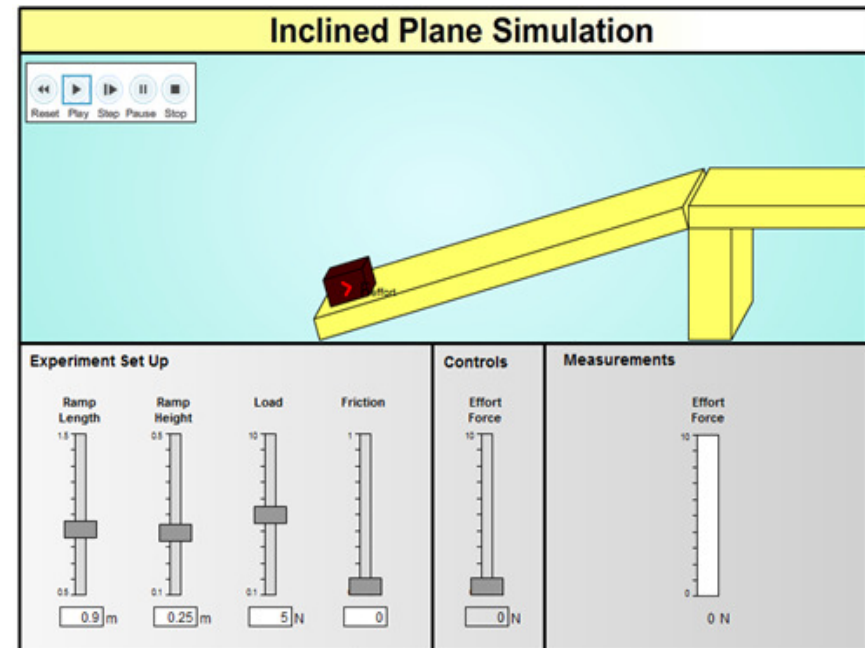
Friction is a [force](#) that resists motion and makes doing [work](#) seem harder because more effort must be applied to complete the task. Think about using an [inclined plane](#) to move an object. As the object slides on the inclined plane, the surface of the object and the surface of the inclined plane rub together and create friction. If the surface of the inclined plane is really bumpy and rough, the object will go down a lot slower than if the inclined plane was smooth. When the object is smooth, there is less friction. Another way to decrease friction when using an inclined plane is to put the object in a cart with wheels. Using wheels will help you roll the object up instead of sliding it, minimizing the friction. The [efficiency](#) of an inclined plane depends on the amount of friction. The less the friction, the more efficient the inclined plane.



# Virtual Environment



Length and Height  
Experiment Simulation



Friction Experiment  
Simulation

# Treatment Groups

Section	Manipulatives	Variables Changed	N
1	Physical	Length & Height	29
2	Virtual	Length & Height	37
3	Physical	Length & Friction	25
4	Physical	Length & Friction	30
5	Virtual	Length & Friction	33

# **Inclined Planes Curriculum**

1. Pre-test
2. Anticipation Guide
3. Individual Predictions
4. Group Predictions and Questions
5. Research on CoMPASS
6. Physical and Virtual Activities
7. Open Ended Summary Questions
8. Answer to Challenge
9. Post-test

# Pre and Post Test Results

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%

- LH Physical and LH Virtual are statistically the same on the pre-test ( $p=.9878$ )
- LH Virtual is statistically significantly higher than LH Physical on the post-test ( $p=.0008$ )
- No statistical difference between LF groups.

# Questions Leading to Difference

Four questions had 20% or more difference between LH Physical and LH Virtual on the post test.

Question	LH Physical	LH Virtual
6.2	21%	78%
7	21%	49%
14	3%	86%
15	28%	49%

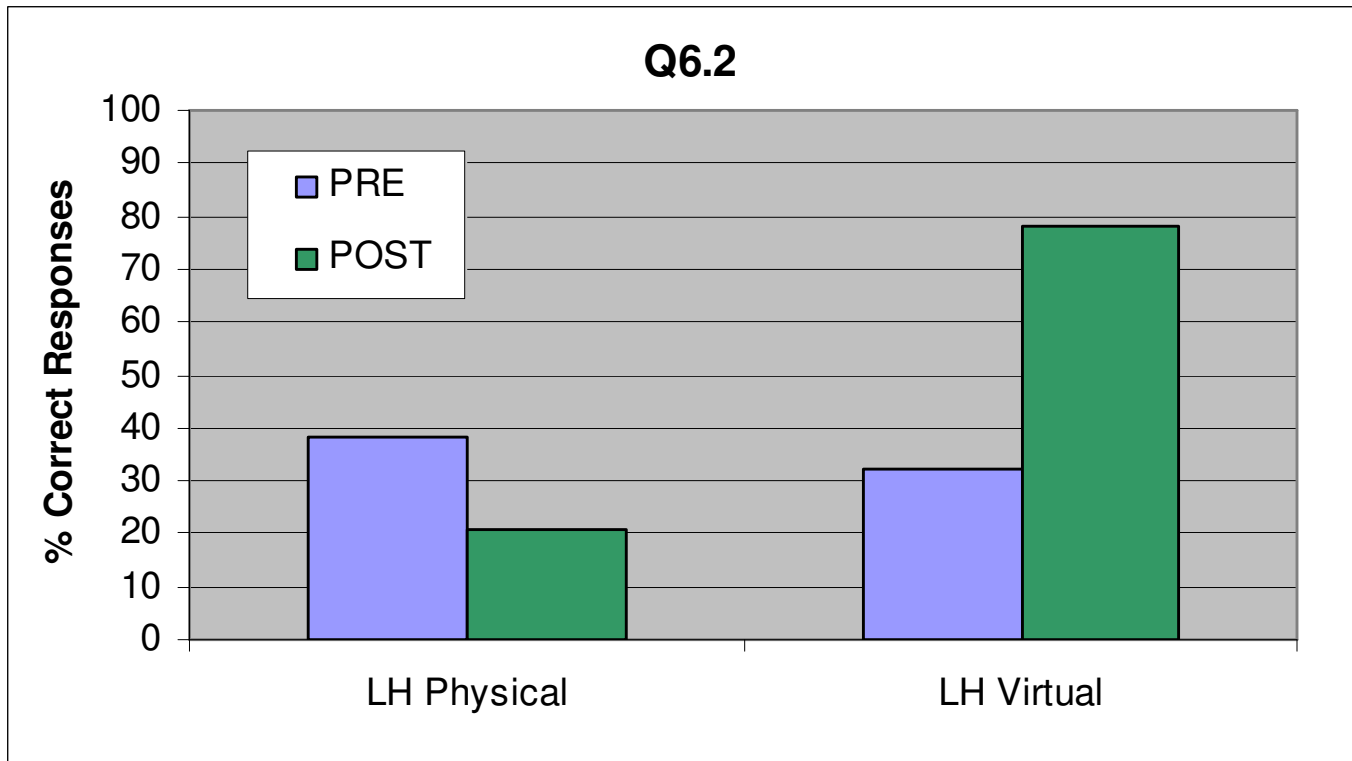


## Question 6.2

You used a 5 meter long ramp with no friction to move an object into a van. If you were to use a 10 meter long ramp with no friction to move the object into the same van the *work* done would:

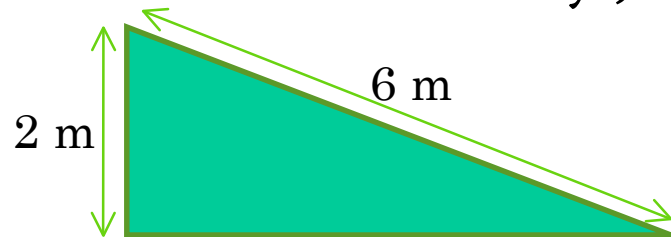
LH Post Test Answers	Physical	Virtual
A. Increase	55%	11%
B. Decrease	24%	11%
C. Stay the same	21%	78%
D. Not enough information to decide	0%	0%

# Question 6.2



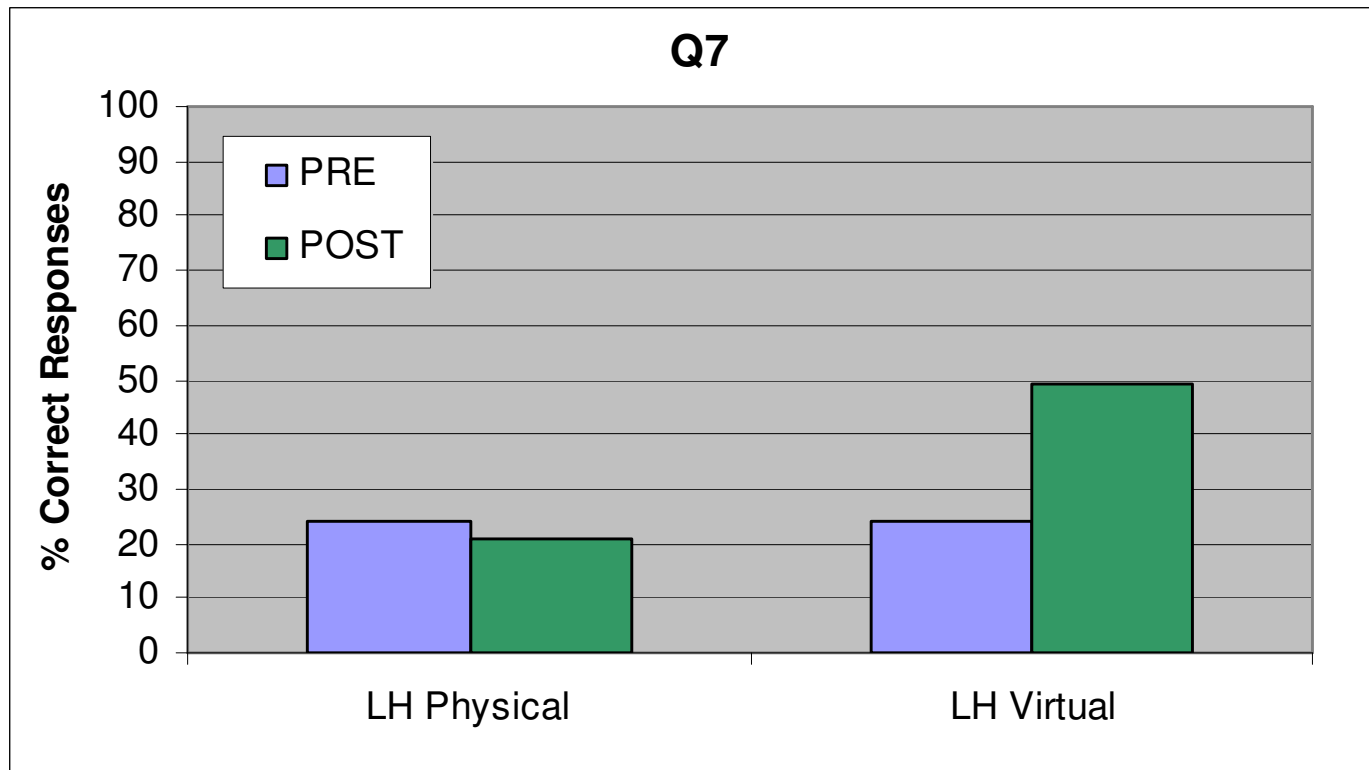
# Question 7

Jane is lifting a box straight up to a height of 2 meters. Mary is using the ramp shown below. If friction is not a factor, what can you tell about the *work done* by Jane and Mary?



Post Test Answers	Physical	Virtual
A. Jane is doing more work	38%	48%
B. Mary is doing more work	38%	3%
C. Jane and Mary are doing the same work	21%	49%
D. Not enough information to decide	3%	0%

# Question 7

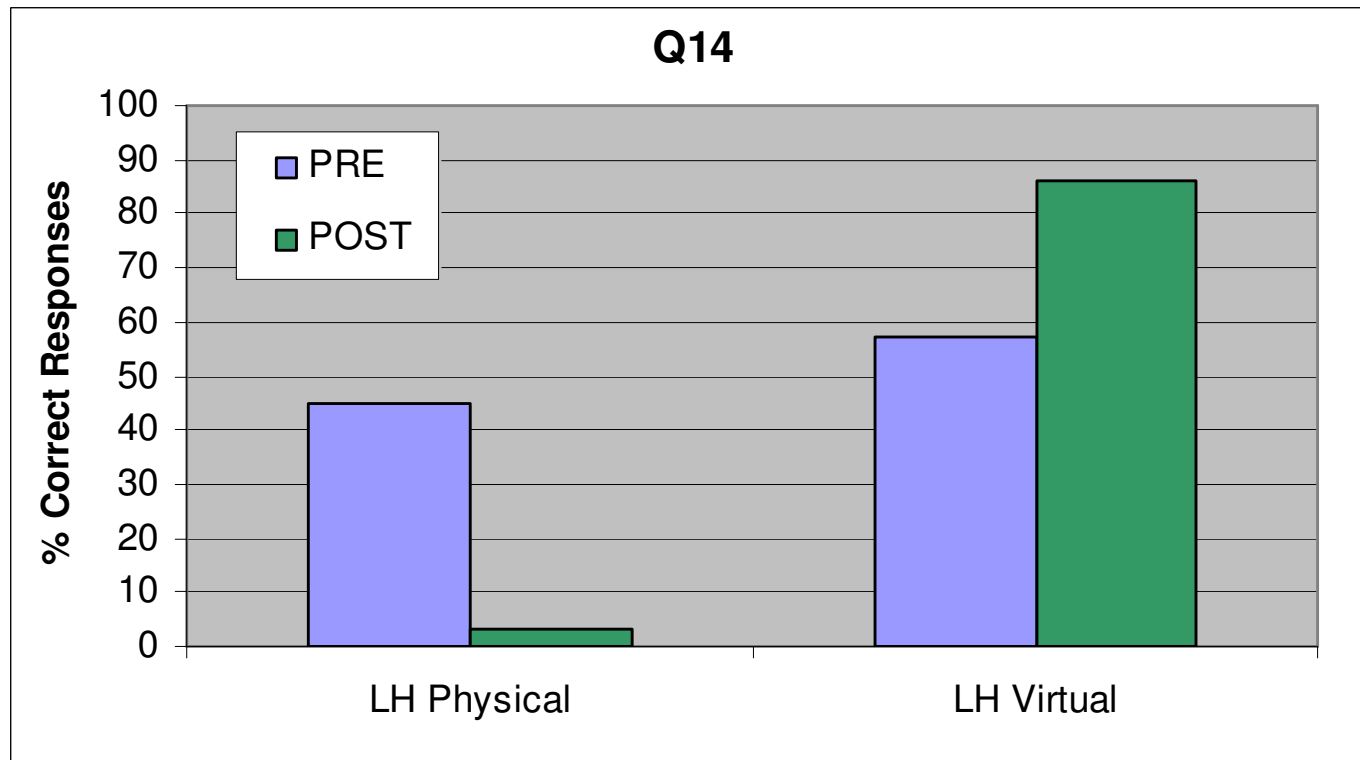


# Question 14

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

Post Test Answers	Physical	Virtual
A. The object's potential energy is greater than the required work.	28%	8%
B. The objects potential energy is less than the required work.	69%	0%
C. The object's potential energy is the same as the required work	3%	87%
D. Not enough information to decide	0%	5%

# Question 14

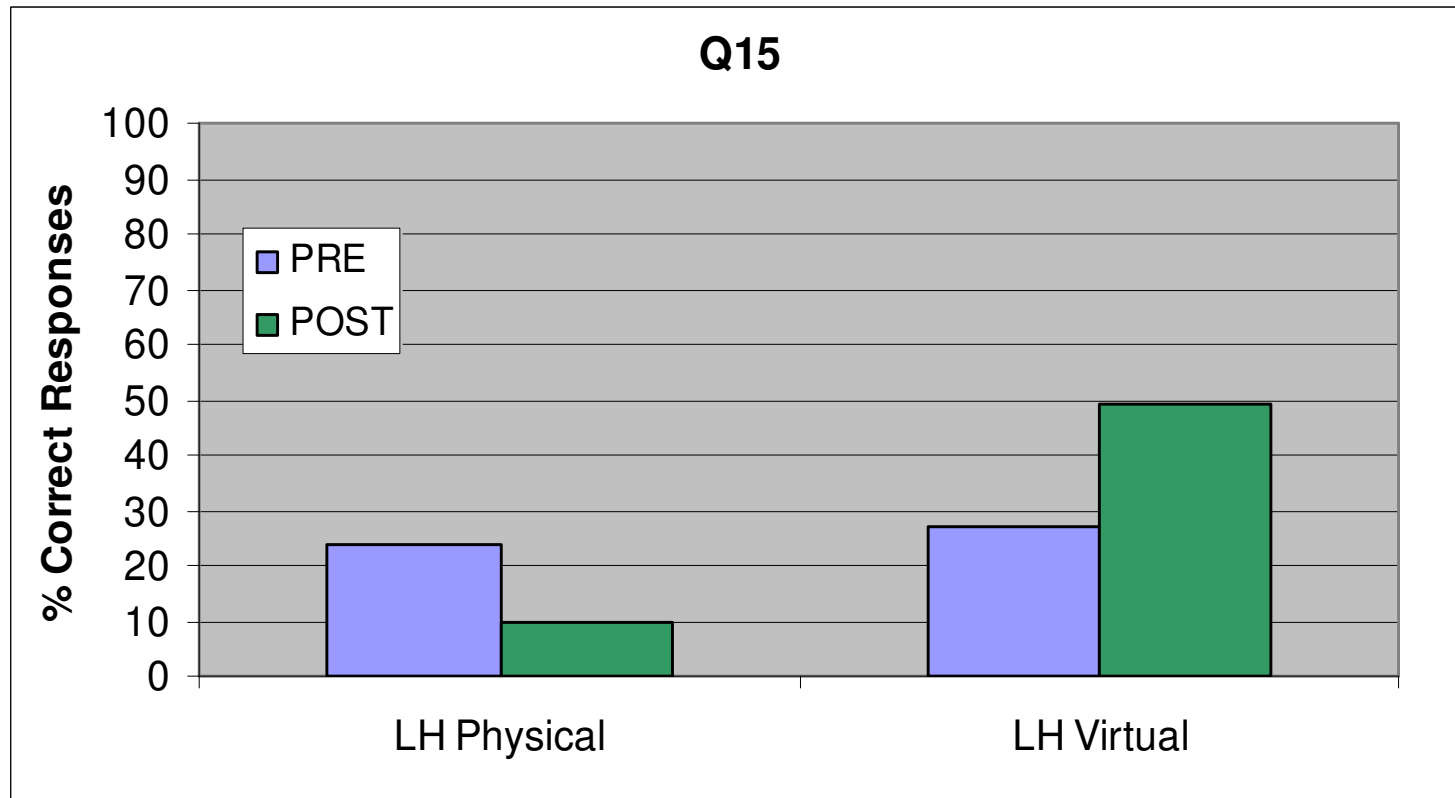


# Question 15

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

Post Test Answers	Physical	Virtual
A. Ideal MA is always greater than Actual MA	48%	21%
B. Ideal MA is always less than Actual MA	14%	8%
C. Ideal MA can be equal to or less than Actual MA	10%	22%
D. Ideal MA can be equal to or greater than Actual MA	28%	49%

# Question 15





# Conclusions

- Students who completed the virtual experiment with length and height did better on a post test than students who performed the physical experiment.
- We identified four questions that had significant contributions to this difference.
- These questions all involved knowledge of a frictionless environment.

# Conclusions

- Students seem to answer conceptual questions based on the experiment performed (virtual or physical).
- Students have trouble extrapolating to a frictionless situation when they have performed the physical experiment.
- In this context simulations provide a better learning experience because they create contexts which are impossible in the real world.
- BUT...

# Conclusions

- Frictionless environments aren't realistic.
- We want students to reason about friction in both environments.
- Future work looks at student understanding and reasoning as they move between environments.