CoMPASS Project Update: Modeling Simple Machines with Simulations

Jacquelyn J. Chini
Adrian Carmichael
N. Sanjay Rebello

OUTLINE

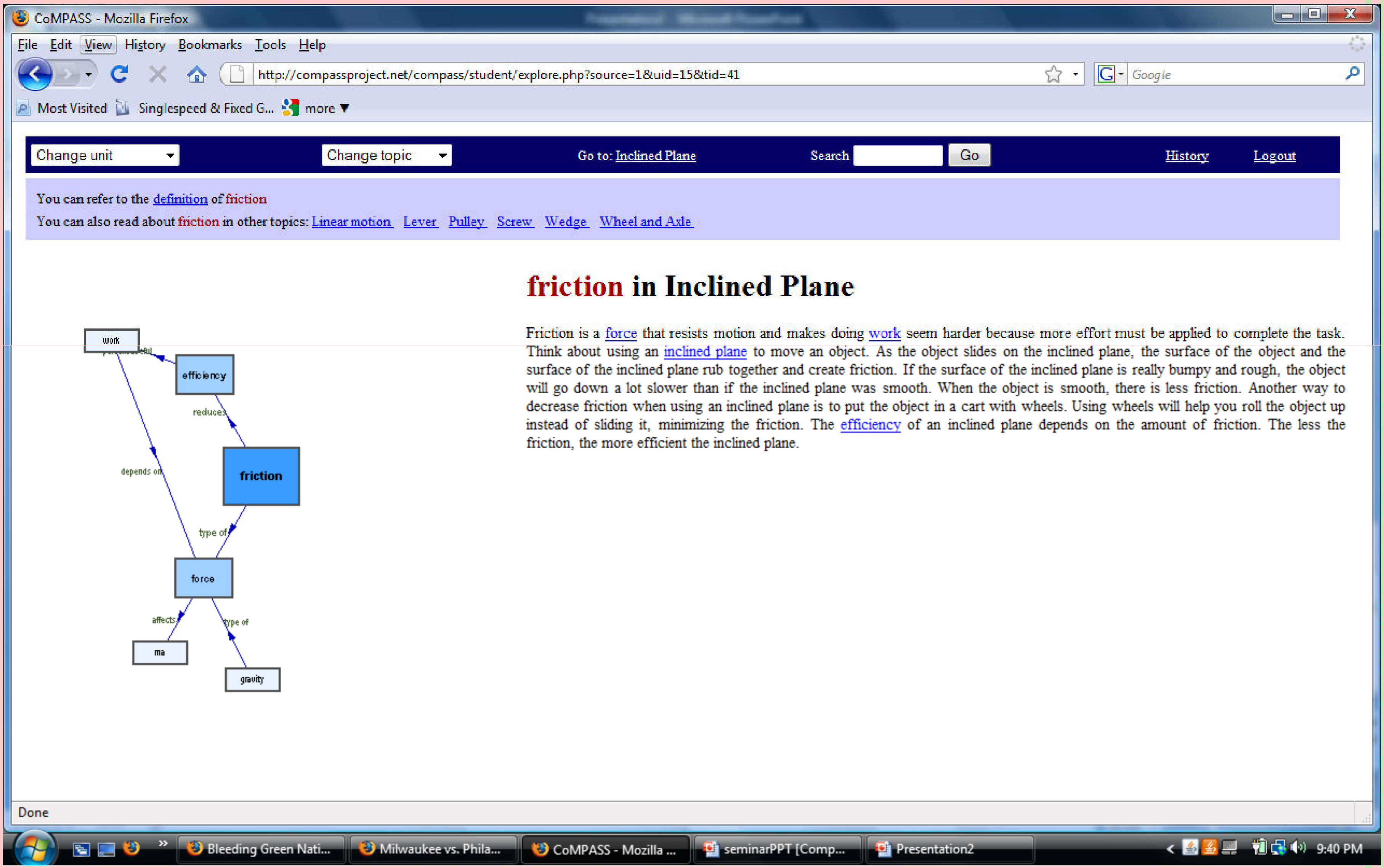
- CoMPASS Overview
- Simulations in Physics- Lit Review
- KSU Studies
- Preliminary Data
- Connection to Dynamic Transfer
- Wrap Up

CoMPASS Project

- CoMPASS…
  - Stands for Concept Map Project-based Activity Scaffolding System
  - Brings together hypertext system, with textual and graphical representations (concept maps), and designed-based challenges

- The CoMPASS curriculum…
  - Originally: Targets students in grades 6, 7, and 8
  - This project: Also with conceptual physics undergrads
  - Focus on simple machines

CoMPASS



CoMPASS - Mozilla Firefox
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http://compassproject.net/compass/student/explore.php?source=1&uid=15&tid=41
Most Visited Singlespeed & Fixed G... more
Change unit
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Go to: Inclined Plane
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You can refer to the definition of friction
You can also read about friction in other topics: Linear motion Lever Pulley Screw Wedge Wheel and Axle
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.
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Previous Research on CoMPASS

- Student use of index vs. concept maps for navigation
  - Map supported goal related, focused navigation
  - No difference in factual knowledge, but students who used maps showed greater depth of knowledge

- Types of navigational support students need
  - Reflect on goals when selecting topics
  - Understand representation of information
  - Visit concepts across different topics

Puntambekar & Stylianou (2005)

CoMPASS Instructional Units

- Based on Learning By Design
  - Overall Design Challenge: Can-Lift Challenge
  - Mini Challenges:
    - Inclined Planes- Design the best ramp to move pool table
    - Pulley- Design the best pulley to lift water bottle
- Real and Virtual Experiments

Kolodner (2003)

Micro-computer Based Labs for Kinematics: Thorton & Sokoloff

- Used motion detectors with software to display real-time graphs of position/velocity/acceleration
  - Do not require special knowledge of computers
  - Students choose representation of data
  - Curriculum based on educational research
  - NOT a simulation- student bodies and carts

- Performance on pre- and post-tests
  - Focused on kinematics concepts and graphical rep.
  - Compared lecture (pre-test) to MBL materials (post-test)
  - Saw significant improvement immediately after MBL and retention of improvement on final exam
    - Most students miss all but simplest problem on pre-test
    - Error rate drops below 10% on all Q's after MBL

Thornton & Sokoloff (1990)

Thornton & Sokoloff- Important Characteristics of MBL Environment

1. Students focus on the physical world.
2. Immediate feedback is available.
3. Collaboration is encouraged.
4. Powerful tools reduce unnecessary drudgery.
5. Students understand the specific and familiar before moving to the more general and abstract.

Note: These conditions are made possible by the combination of tools, curriculum, and setting.

Thornton & Sokoloff (1990)

Tutorials Using MBLs- Velocity and Newton's Third Law

- Used active-engagement MBL-based tutorials with sonic ranger and force probe
- Replaced 1 hour recitation with 1 hour tutorial
- Evaluated learning with T&S's and FCI M.C. Q's plus long-answer exam problem
  - MBL students performed better on velocity Q's
  - MBL students had h=.64 compared non-MBL students with h=.28 for Newton's 3rd Q's on FCI
  - On open-ended velocity Q
    - 22% of MBL correct vs. 12% of non-MBL
  - On open-ended Newton's 3rd
    - 55% of MBL correct vs. 42% of non-MBL

Redish, Saul, & Steinberg(1997)

Redish *et al.*- Important Characteristics

- Agrees with Thornton & Sokoloff
  - Consistent with modern theories of learning, including those based on Piaget and Vygotsky
  - Consistent with current understanding of structure of short and long-term memory buffers

- Adds an additional conjecture:
  - Students are actively engaged in exploring and constructing their own understanding

Redish, Saul, & Steinberg(1997)

Transition to Simulations

- Why use simulations?
  - Explore impractical or impossible physical situations
    - Adjust gravity or friction
    - Observe particle motion in an ideal gas
  - BUT this is a different way of learning

Steinberg(2007)

Simulating Air Resistance

- Steinberg compared use of simulation to pencil-and-paper activities with computer simulation
  - Both “interactive learning environments” (Tutorials)
  - Same content and level of interactive engagement
  - With sim, students compare pre... graphs
  - Without sim, students ... diagrams to Newton’...
- Class ... to encou...
  - Stu...
  - Da... correct ans...
- Exam question: contrast air resistance & friction
  - All students improved from pretest
  - Performance of the two sections was NOT significantly different

Ball “goes to a shallower height because the graph...

Results seem NOT to be tied to simulation

Steinberg(2007)

Simulating Circuits

- Finkelstein et al examined replacing a circuit lab with a computer simulation
  - Both labs emphasized discovery over verification
  - Lab involved examining resistors in series and parallel, building a simple circuit, predicting behavior of circuit elements, developing methods to measure resistance
  - Sim group used Circuit Construction Kit (CCK)
  - Pre-lab, lab, and challenge activities were matched
    - Main challenge was to build circuit with REAL equipment
- Performance on Circuit Challenge
  - CCK students completed activity faster
  - CCK students had stat. sig. better written explanations
- Final Exam questions
  - CCK students performed stat. sig. better on circuit questions, but similarly on remaining exam questions

Finkelstein, *et al.* (2005)

Finkelstein et al- Important Characteristics

- Computers can make visible the models that are useful for forming concepts
  - CCK explicitly shows flow of electrons
- Computers can constrain students in productive ways

- Redish: "Is the computer appropriate for teaching physics?"
  - Finkelstein: "We suspect its time may have arrived."
- Steinberg: "To simulate or not to simulate?"
  - Finkelstein: "Yes… providing simulations are applied in appropriate contexts."

Finkelstein, *et al.* (2005)

KSU Studies

Semester	Context	Conditions	Class
F07	Inclined Plane	Real Only	COP
F08	Inclined Plane	Real AND Virtual	COP
F08	Forces & Motion	Real	PW2
S08	Inclined Plane	Real OR Virtual	PW Lab
S08	Inclined Plane	Real AND Virtual	MS
S08	Pulley	Real AND Vir[illegible]	PW1/DP
S08	Pulley	Real AN[illegible]tual	PW Lab
S08	Pul[illegible]	[illegible]	MS

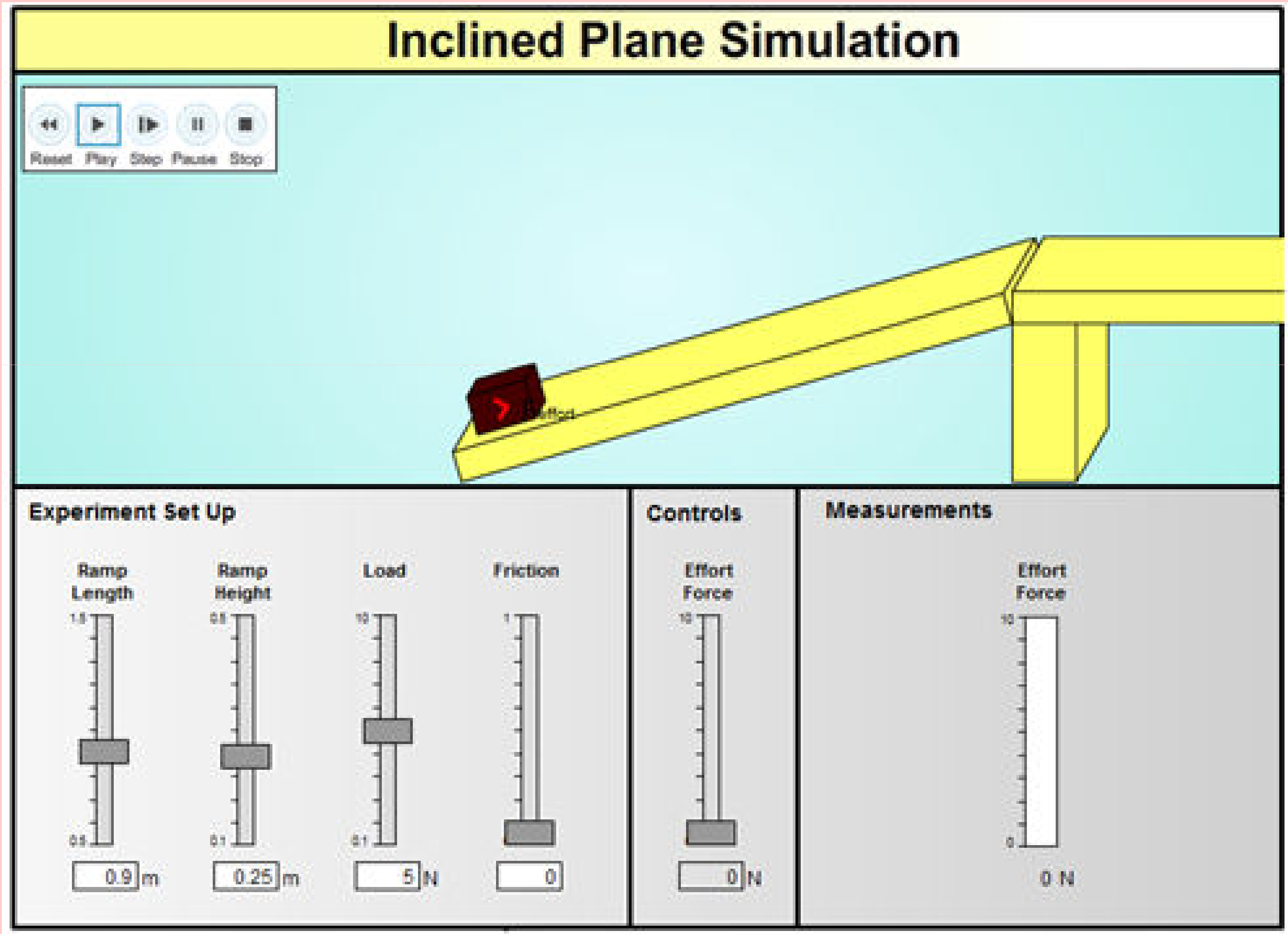
Difficulties with accessing websites using middle school's internet

Inclined Planes Curriculum

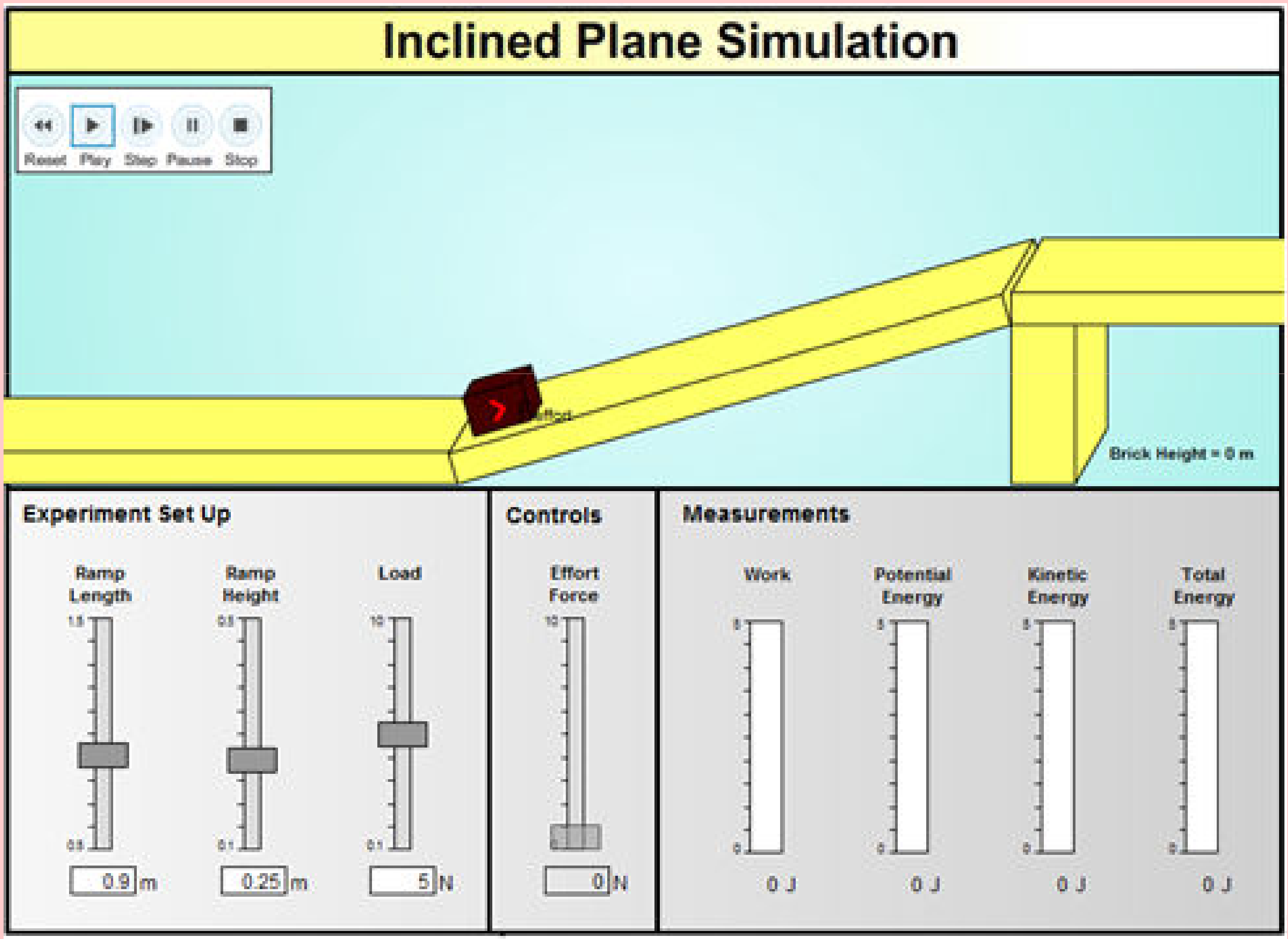
- Pre-test
- Anticipation Guide
- Predictions
- Group Questions
- Research on CoMPASS
- Activities
- Analysis Questions
- Challenge
- Post-test

Inclined Plane Hands-on Activity

Inclined Planes Simulation- Length and Friction



Inclined Planes Simulation- Height



Comparison of F08 and S09 Implementations

Fall 2008

- Concepts of Physics
- Extra Credit
- Interview Room
- Videotaped
- I… n/ J…
- I…
- Length/Height <u>or</u> Length/Friction <u>or</u> Height/Friction <u>or</u> All

Order Effects?

Spring 2009

- Physical World
- Graded
- Actual lab room
- N…
- I… <u>nd</u> A… jay
- I…
- Length/Height <u>or</u> Length/Friction

Is real or virtual better?

Data Collected

- Videotapes from Interview Room
- Observational Notes from Labs
  - Facilitator
  - TA
  - Undergrad observer (for some)
- All student worksheets
- All pre- and post-tests

S09 Pre- and Post-Test Results

Section	Pre-Test	Post-Test
LH Real	59.91%	66.16%
LH Virtual	59.97%	77.53%
LF Real	59.24%	66.03%
LF Real	60.08%	65.93%
LF Virtual	56.67%	67.08%

- LH Real and LH Virtual are statistically the same on the pre-test ($p=.9878$)
- LH Virtual is statistically significantly higher than LH Real on the post-test ($p=.0008$)

What questions lead to this difference?

Questions Leading to Difference

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

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

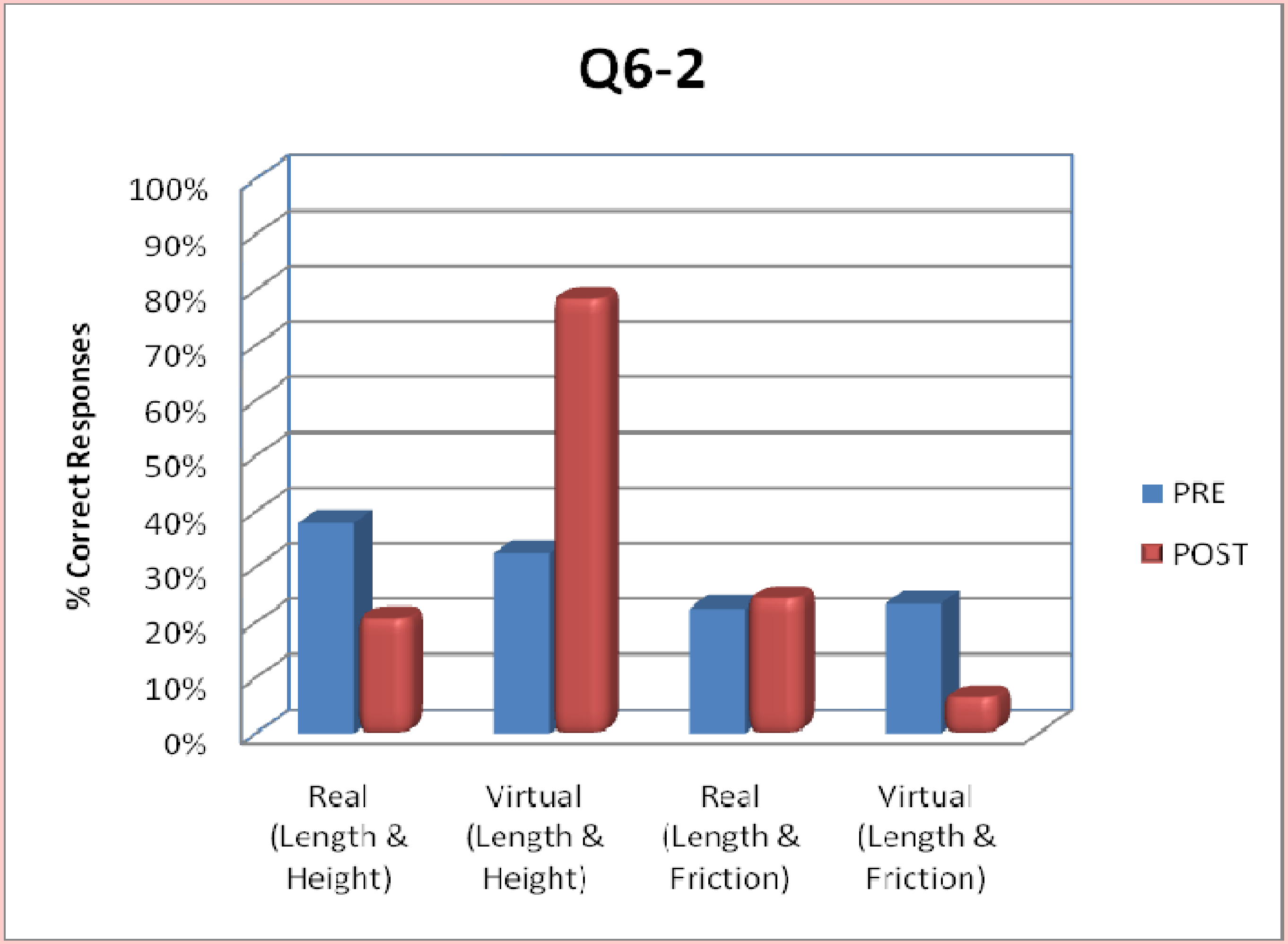
Question 6.2

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:

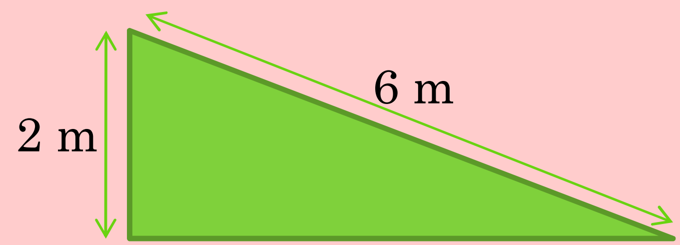
Answers	Section A	Section B
A. Increase	55%	11%
B. Decrease	24%	11%
C. Stay the same	**21%**	**78%**
D. Not enough information to decide	0%	0%

Appears to deal with changing length at a constant height, but frictionless context seems to cause difficultly.

Question 6.2- Whole Class Performance



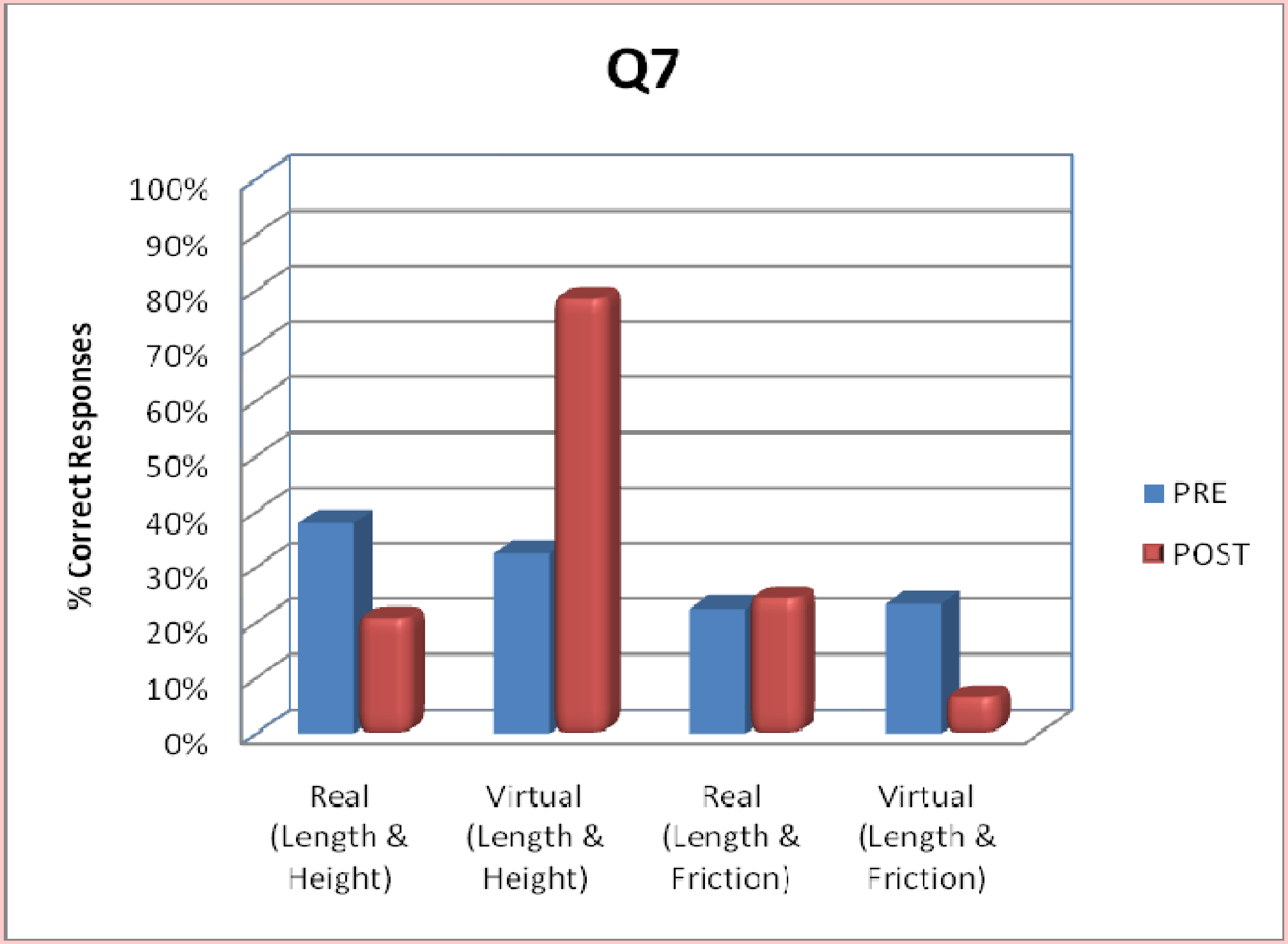
Question 7



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?

Answers	Section A	Section B
A. Jane is doing more work	38%	49%
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- Whole Class Performance

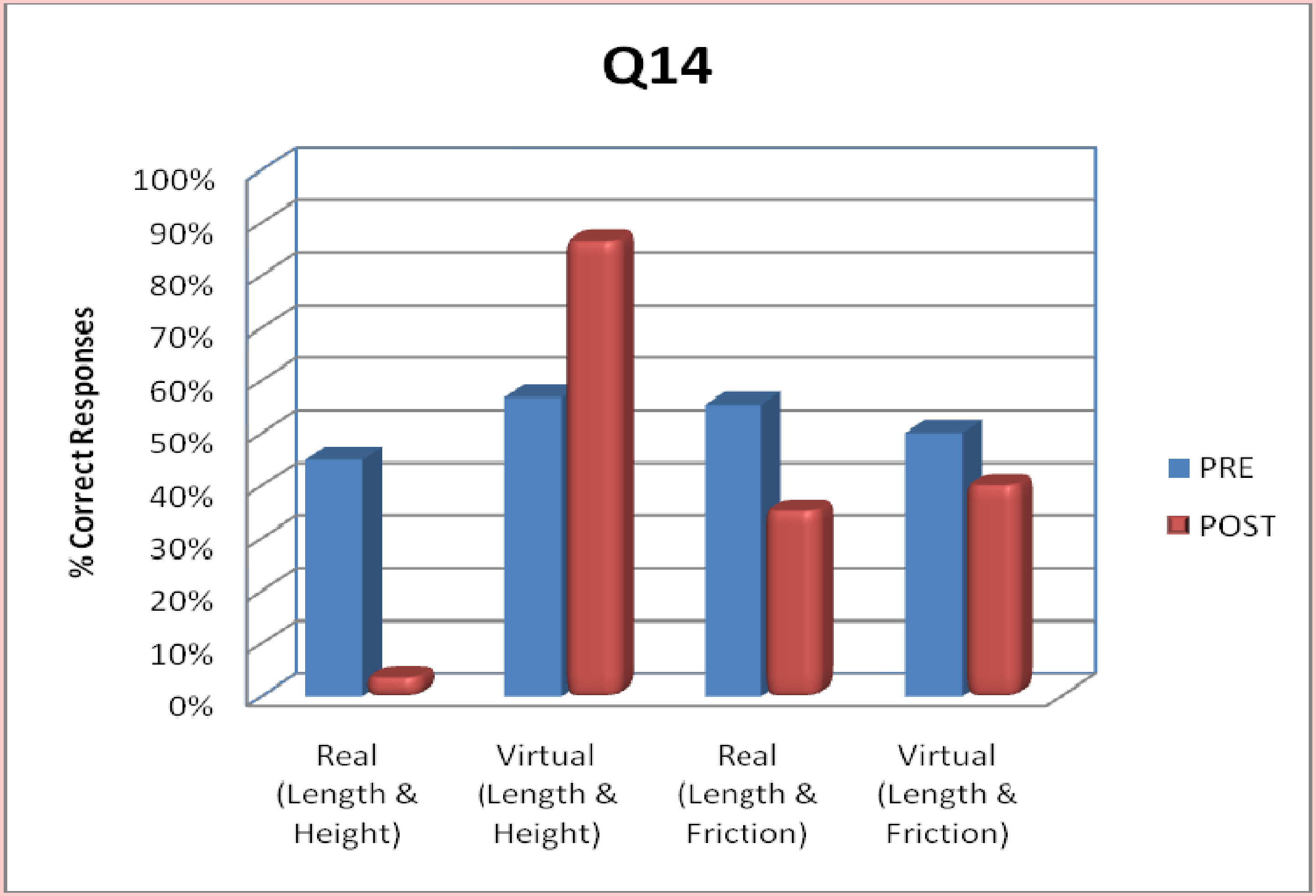


Question 14

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?

Answers	Section A	Section B
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%**	**86%**
D. Not enough information to decide	0%	5%

Question 14- Whole Class Performance

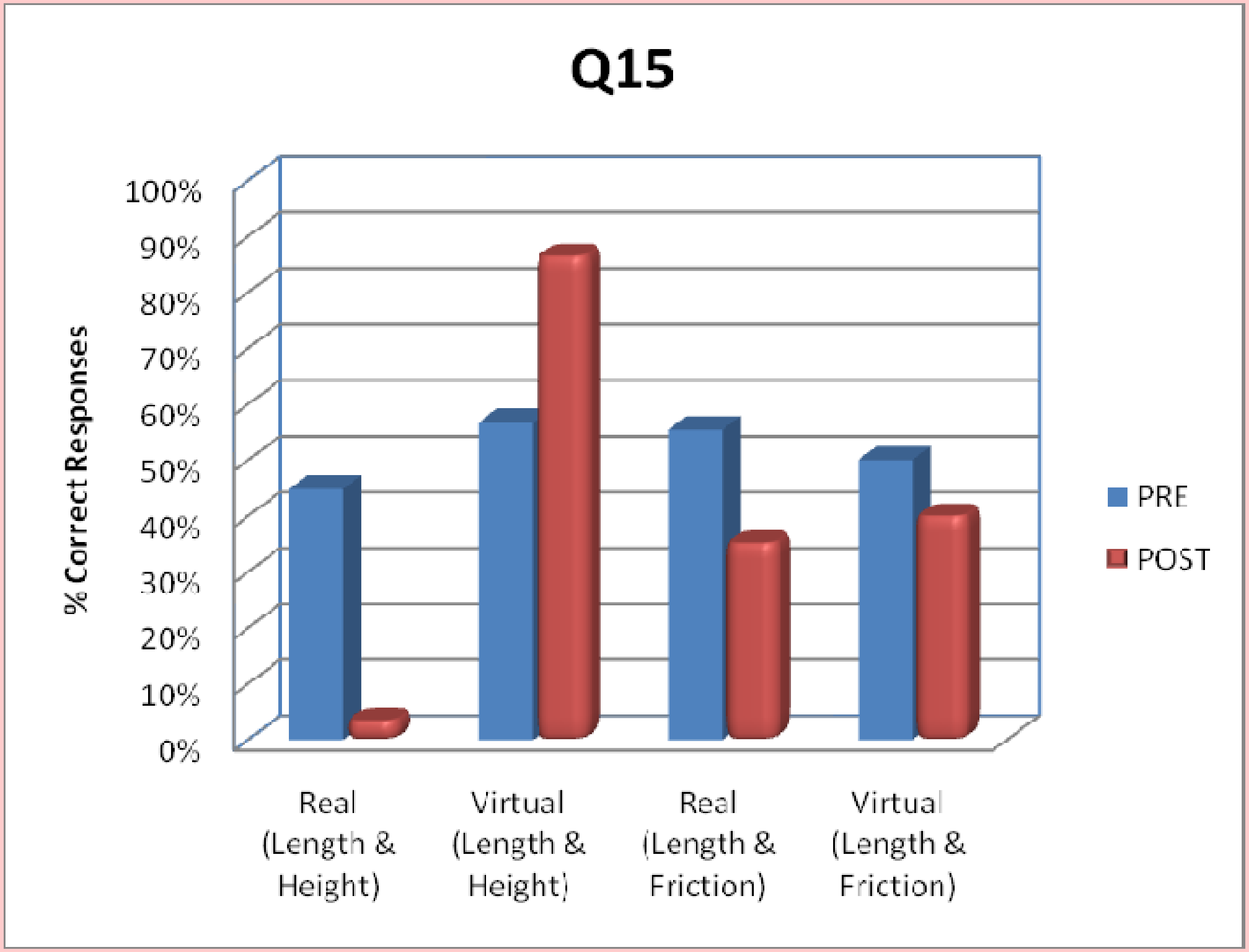


Question 15

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

Answers	**LH Real**	**LH Virtual**
A. Ideal MA is always greater than Actual MA	28%	22%
B. Ideal MA is always less than Actual MA	69%	8%
C. Ideal MA can be equal to or less than Actual MA	**3%**	22%
D. Ideal MA can be equal to or greater than Actual MA	0%	**49%**

Question 15- Whole Class Performance



Emerging Trends

- Students who only performed length and height experiment appear to have difficulty answering questions about a frictionless environment
- Students who did the friction experiment or simulation performed better, but not as well as students who did only length and height simulation
  - LH Virtual students ONLY saw frictionless case

- Questions:
  - Do students written responses show these same trends?
  - When students do LHF do they perform more like LH or LF students?

Dynamic Transfer

- Similarity transfer…
  - Apply well-formed concepts in a new situation
- Dynamic transfer…
  - "Component competencies are coordinated through interaction with the environment to yield novel concepts or material structures"
  - Tries to explain how prior knowledge can create concepts that did not previously exist
- Distinctions…
  - Knowledge organization: well-formed vs. component
  - Move to achieve transfer: "this is like this" vs. "this goes with that"
  - Role of context: cue retrieval of intact prior knowledge vs. coordinate different components of prior knowledge through interaction

"Dynamic Transfer and Innovation" Schwartz, Varma, & Martin

Environment for Dynamic Transfer

- Schwartz discusses the characteristics of an environment that supports dynamic transfer
  - Allows for distributed memory
    - Store intermediate products of learner's work
    - Affordances and constraints that encapsulate rules
  - Offers alternative interpretations and feedback
  - Offers candidate structures by constraining and structuring possible actions
    - Similar to scaffolding
  - Provides a focal point for coordination
    - Allows student to bring together different pockets of knowledge and coordinate them

"Dynamic Transfer and Innovation" Schwartz, Varma, & Martin

Conditions for Successful Use of Computers in Labs

1. Students focus on the physical world.
2. Immediate feedback is available.
3. Collaboration is encouraged.
4. Powerful tools reduce unnecessary drudgery.
5. Students understand the specific and familiar before moving to the more general and abstract.
6. Students are actively engaged in exploring an[d] constructing their own understanding
7. Useful models for forming concepts are made visible.
8. Students are constrained in productive way[s]

Thornton & Sokoloff

Redish *et al.*

Finkelstein *et al.*

Dynamic Transfer in Simulations… Are There Connections?

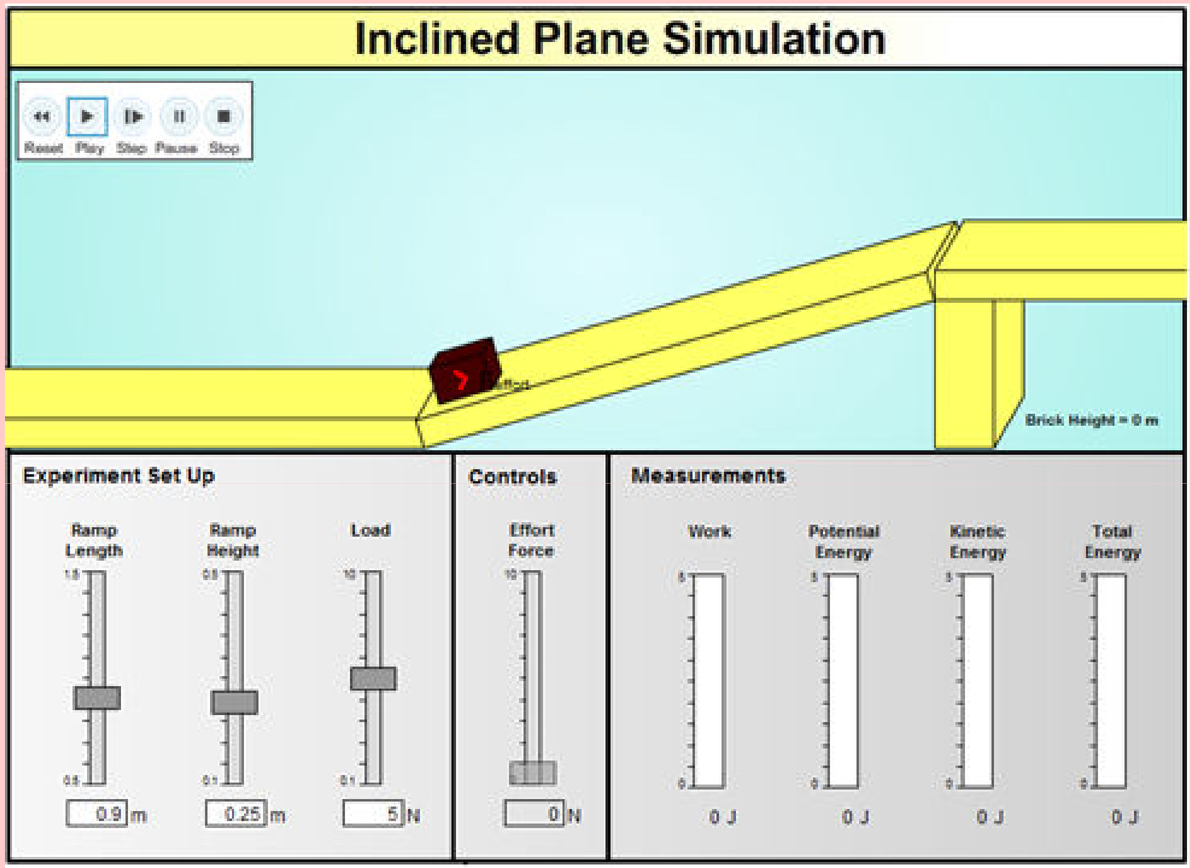
Properties of Successful Computer Use

1. Focus on the physical world.
2. Immediate feedback is available.
3. Collaboration is encouraged.
4. Powerful tools reduce drudgery.
5. Understand the specific and familiar before moving to the more general and abstract.
6. Students are actively engaged in exploring and constructing their own understanding
7. Useful models for forming concepts are made visible.
8. Students are constrained in productive ways.

Characteristics of Environment for D.T.

1. Allows for distributed memory.
2. Offers alternative interpretations and feedback.
3. Offers candidate structures by constraining and structuring actions.
4. Provides a focal point for coordination of different knowledge pockets.

Analysis of Our Simulation



1. Distributed memory.
2. Alternative interpretations and feedback.
3. Constrains and structures actions
4. Provides a focal point for coordination

QUESTIONS TO THINK ABOUT…

- Can students who only use simulation perform tasks with real equipment?
  - Steinberg says no
  - Finkelstein says yes
- Are students who use the simulation in a different epistemic mode that those who use real equipment?
  - If yes, can we change it?
- Does the real experiment differ from the virtual experiment in the affordances in provides for dynamic transfer?

Summer Plans

- Analyze worksheet responses
- Check validity and reliability of tests
- Open-ended interviews with simulations

Questions for Discussion

1. How much social interaction & scaffolding is (optimally?) provided by the facilitator in the group interviews?
2. In what ways should we consider how the simulations affect students' epistemic frames for future learning?
3. How do you think switching to a computer-based system would affect students' responses to subjective questions?
4. Do you think the results would be different if students worked with the simulation materials as individuals?
5. Do you see dynamic transfer? Can we encourage or suppress dynamic or similarity transfer? Will doing so better teach students how and when to use an innovative or efficient problem solving approach?