

Examining the Combination of Physical and Virtual Experiments in an Inquiry Science Classroom



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Overview

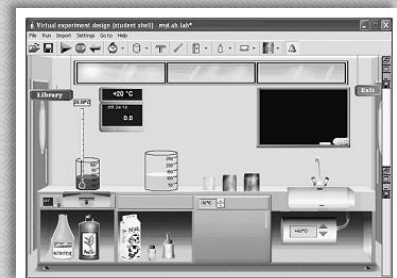
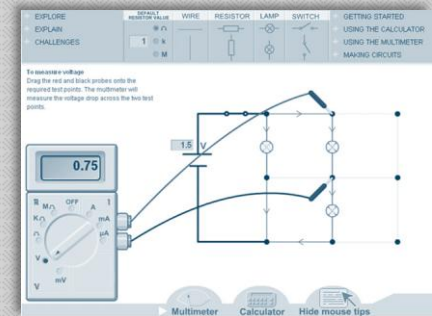
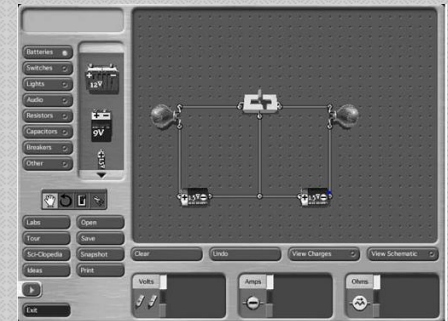


- **Background**
 - Previous Research on Comparing and Combining Physical and Virtual Experiments
 - Affordances and Constraints of Physical and Virtual Experiments
- **Study**
 - Combining physical and virtual experiments in a middle school inquiry science unit on pulleys
 - ✦ Sequence of activities
 - ✦ What each form of activity supports
- **Implications and Future Research**

Comparing and Combining Physical and Virtual Experiments



- Comparing Physical and Virtual Experiments
 - Simulations and physical investigations have traditionally been treated as competing methods for science learning (Jaakkola & Nurmi, 2008)
 - Results: Simulations better than (e.g. Finkelstein et al., 2005) or equivalent to (e.g. Klahr, Triona & Williams, 2007) physical experiments
- Combining Physical and Virtual Experiments
 - More recent research has begun to investigate combining physical and virtual experiments
 - Results: Physical-Virtual Combination better than (Zacharia, 2007; Jaakkola & Nurmi, 2008) or equivalent to (Zacharia & Olympiou, 2010) physical or virtual alone



Affordances and Constraints of Physical and Virtual Experiments



Physical Experiments

- **Affordances**
 - Allow students to experience phenomena directly
 - Allow students to gain experience with science practices
- **Constraints**
 - Can take time and/or resources
 - Students may not be able to observe intended phenomenon

Virtual Experiments

- **Affordances**
 - Can provide new opportunities for exploration
 - Focus attention on formal variables
 - Can provide representations of variables not available in the real world
- **Constraints**
 - Decontextualized representations
 - Relationships must be programmed in advance

Research Questions



- In a middle school simple machines curriculum, does adding virtual experiments to existing physical experiments help students learn pulley concepts?
- When combining physical and virtual experiments, is the *sequence* of activities important for student conceptual learning?
- Assuming there are different affordances and constraints of each form of investigation, do students learn different concepts from physical and virtual investigations?

Methods



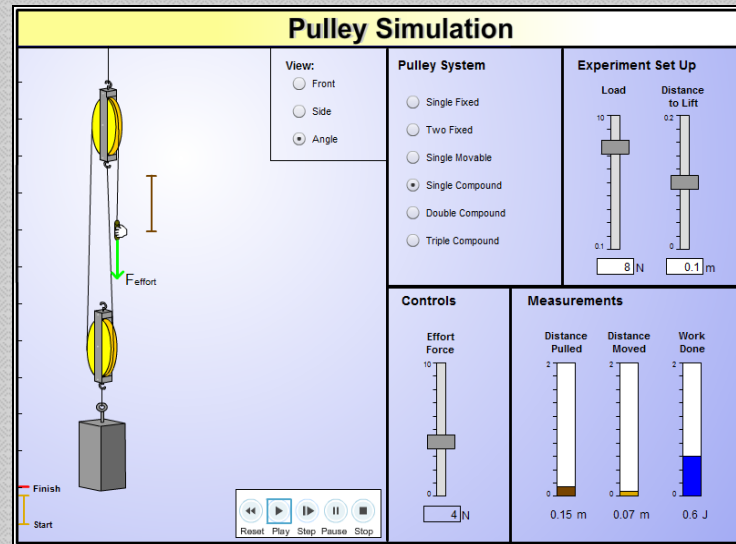
- Three 6th grade science classes in Midwestern US middle school
 - ✦ 11-12 year old students
 - ✦ All classes taught by same teacher

- Pulley systems section of CoMPASS simple machines curriculum (Puntambekar, Stylianou & Goldstein, 2007)

- Students worked in small groups (3-4)

- Two conditions:
 - ✦ Physical-Virtual (N=43)
 - ✦ Virtual-Physical (N=17)

Learning Environments



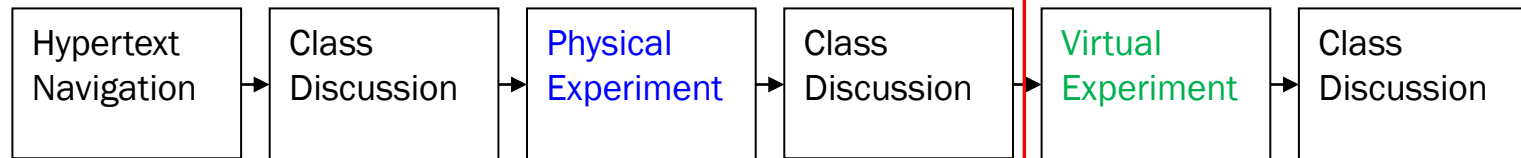
- Allow students to experience phenomena directly
 - haptic feedback
- Allow students to gain experience with science practices
 - measurement

- Provide new opportunities for exploration
 - more pulley configurations
 - frictionless environment
- Provide representations of variables not available directly in the real world
 - work

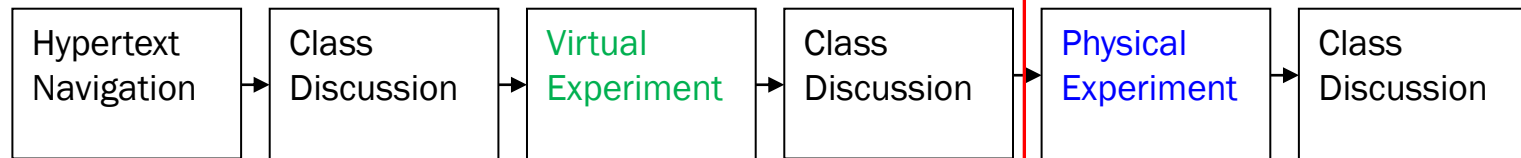
Study Design



Physical-Virtual Condition:



Virtual-Physical Condition:



pre-test

mid-test

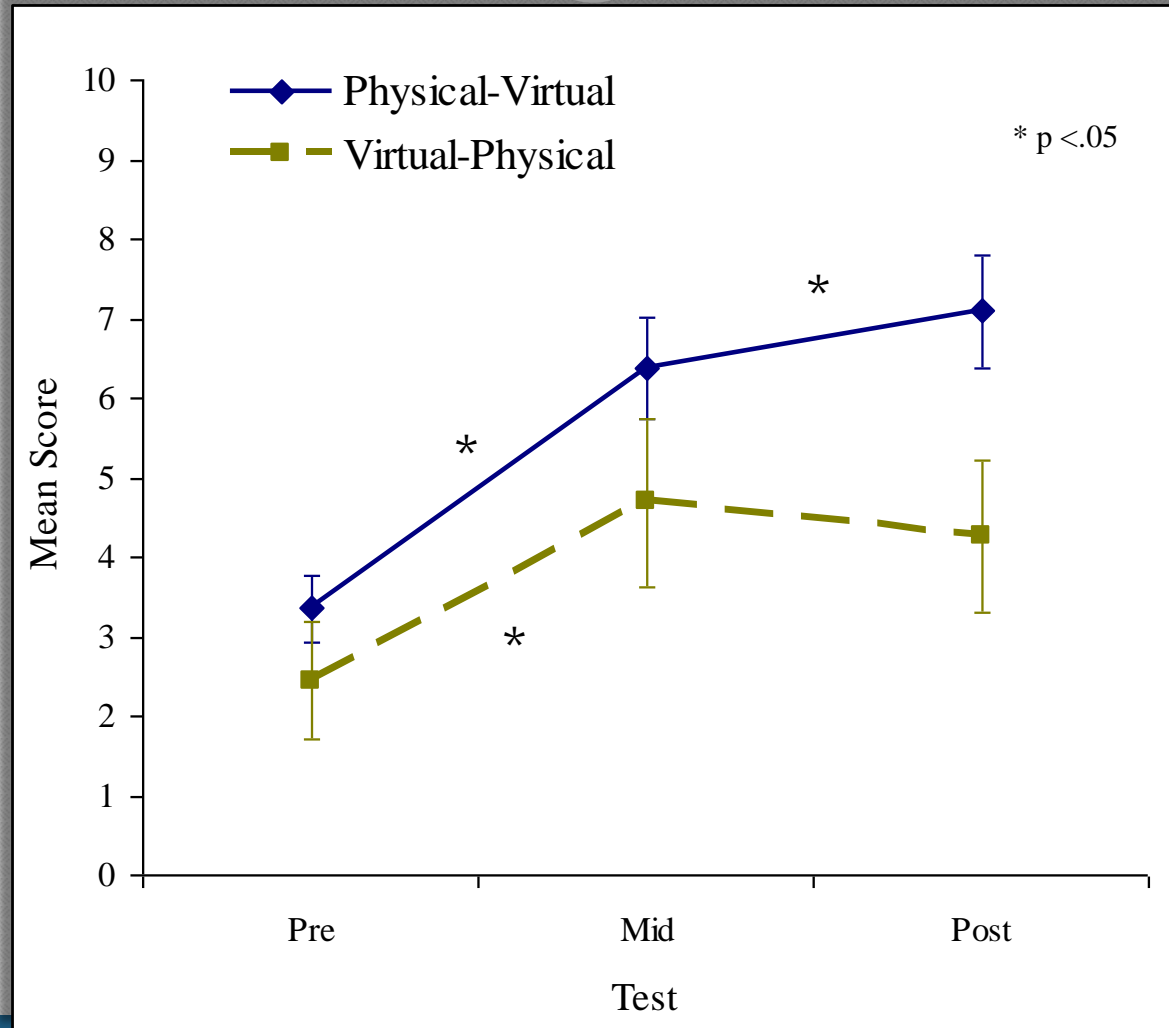
post-test

Pulley Concept Test



Pulley Systems	Physics Concepts
Single Fixed vs. Single Movable	Force (2 items) Mechanical Advantage (1 item) Distance pulled to lift an object (1 item)
Single Fixed vs. Two Fixed	Force (1 item) Mechanical Advantage (1 item)
Single fixed vs. Single Movable vs. Two Fixed vs. Double Compound	Force (1 item) Mechanical Advantage (1 item)
Single Fixed vs. Single Compound vs. Double Compound	Work done when lifting to same height (1 item)
Fixed Pulley	Work done when lifting to different heights (1 item)

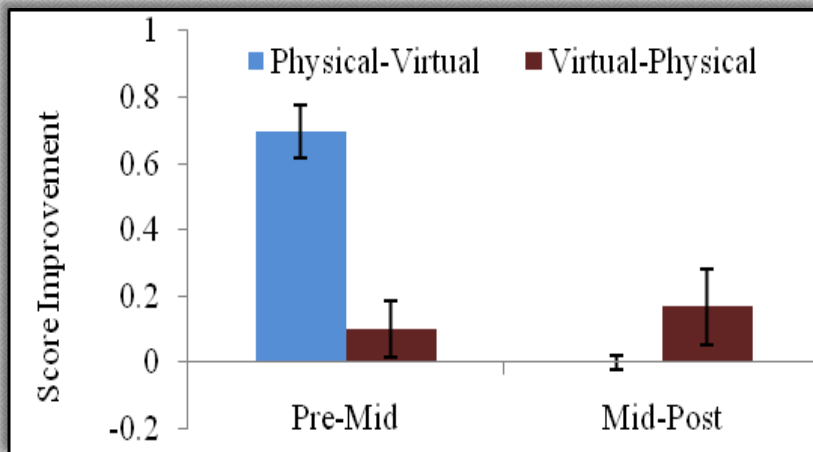
Results



Results

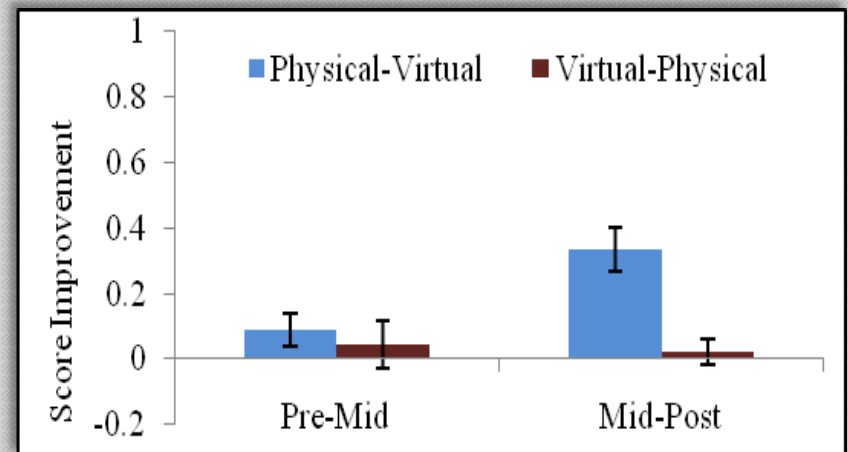


Items Learned from Physical Experiment First



- Force and Mechanical Advantage in a Single Fixed vs. Single Movable Pulley (2 items)

Items Learned from Virtual Experiment Second



- Force and Mechanical Advantage in a Single Fixed vs. Two Fixed Pulleys (2 items)
- Comparing work done using different pulley systems, lifting to same height (1 item)

Discussion



- Physical-then-Virtual > Virtual-then-Physical
 - Direct physical experience first then test conceptions in more flexible simulations
 - ✦ Concrete to abstract
 - In other studies (e.g. Zacharia & Anderson, 2003; Jaakkola & Nurmi, 2008) students use a simulation *prior to* physical experiment.
 - ✦ Simulation as “cognitive framework” (Zacharia & Anderson, 2003)
- What factors may be important?
 - Affordances and constraints of the physical and virtual activities
 - Nature of the content
 - Prior knowledge
 - Age/Development

Study Limitations



- Students assigned to condition by class
- Effect of hypertext environment unknown

Conclusions



- Combining physical and virtual experiments was beneficial, but only for students who conducted the virtual experiment *after* the physical experiment.
- Physical and virtual experiments can play different roles in supporting learning
- Sequence of activities can be important
 - The effect of sequence may be driven by the role that each activity is designed to play

Future Research Directions



- Supporting students' linking between the physical and virtual
 - Teacher facilitation
 - Scaffolding within the simulation environment
 - Directly coupling the physical and virtual

- Beyond conceptual learning
 - New opportunities for modeling

Dziękuję!



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