HOW PHYSICAL AND VIRTUAL EXPERIMENTS INFLUENCE STUDENTS’ UNDERSTANDING OF PULLEYS

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Research Questions

- Do physical and virtual manipulatives offer different support for students’ understanding of pulleys?

- Does the sequence in which students perform experiments with physical and virtual manipulatives affect students’ understanding of pulleys?
Previous Studies

- Simulations may offer better support than physical equipment (Finkelstein et al., 2005; Zacharia et al., 2008)

- Simulations and physical equipment may offer equal support (Triona, Klahr & Williams, 2007; Zacharia & Constantinou, 2008)

- Our previous study (Gire et al., 2010):
  - Physical manipulative and Physical-Virtual sequence offered better support for learning about force
  - Virtual manipulative offered better support for learning about work
Description of Current Study

- Conceptual-based physics course for future elementary school teachers
- “Drop-in” style lab
- Students chose sequence of physical and virtual activities

Monday

Pre-test ➔ Physical or Virtual Activity ➔ Mid-test ➔ Virtual or Physical Activity ➔ Post-test

Predictions & CoMPASS

Physical-Virtual: N=59
Virtual-Physical: N=40
work in Pulley

A pulley requires energy in order to do work. This energy is transferred by the force you apply when you pull on the pulley string. Pulleys can reduce the amount of applied force necessary to lift an object when doing work.

The formula for work is:

\[
\text{work} = \text{force} \times \text{distance}
\]

The formula shows how work depends on both force and distance. The distance is how far you pull the string while exerting an applied force. When using a pulley, the amount of force required to move a heavy object depends on the type of pulley you use. Pulleys that decrease the amount of applied force needed to move an object require that you pull the string a greater distance than the object rises. This trade-off between force and distance is called mechanical advantage (MA).

Pulley Simulation

View: 
- Front
- Side
- Angle

Pulley System:
- Single Fixed
- Two Fixed
- Single Movable
- Simple Compound
- Double Compound
- Triple Compound

Experiment Set Up

Control
- Load
- Distance

Measurements
- Effort Force
- Distance Pulled
- Distance Moved
- Work Done
Assessment

- 20 multiple-choice questions
  - Force questions: 7
  - Work & Potential Energy questions: 9

- Cronbach’s alpha = .743

- No significant difference in time from second activity to post-test for the two sequences, t(97) = -.93, p = .357
Total Score equally supported by both manipulatives and both sequences
Mixed ANOVA

Main Effect:  $p < .001$
Interaction:  $p = .147$

Pre-Mid

Main Effect:  $p < .001$
Effect Size:  $r = .78$

Mid-Post

Main Effect:  $p = .575$
Effect Size:  $r = .06$

Force Score equally supported by both manipulatives and both sequences
Work/energy score supported a little better by virtual manipulative but supported equally by both sequences.
Discussion

- In this study:
  - Work score is supported slightly better by simulation
  - Both sequences offer equal support for Total, Force & Work scores

- This does not match previous study. Why?
  - Different population
  - Different format ("drop-in" style lab)
  - Different questions
  - Different timing of test (Heckler & Sayre, 2010)
Thank you!

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