Comparing the Effects of Sequencing of Physical and Virtual Manipulatives on Student Learning and Confidence

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Research Questions

Does the sequence in which students perform experiments with physical and virtual manipulatives affect students’:

- understanding of pulleys?
- confidence in their learning?
- retention of information?
Previous Research

• Simulations may offer better support than physical equipment. (Finkelstein et al., 2005; Zacharia et al., 2008)
  \[ \text{Simulation} > \text{Physical} \]

• Simulations and physical equipment may offer equal support. (Triona, Klahr & Williams, 2007; Zacharia & Constantinou, 2008; Zacharia & Olympiou, 2011)
  \[ \text{Simulation} = \text{Physical} \]

• Our previous study on pulleys (Gire et al., 2010):
  - Physical manipulatives and physical-virtual sequence offered better support for learning about force.
    \[ \text{Physical} > \text{Simulation for Force} \]
  - Virtual manipulatives offered better support for learning about work.
    \[ \text{Simulation} > \text{Physical for Work} \]

Previous Research

• Student Self Reported Preference of Manipulative
  - Test: Virtual
  - Rental Store: Physical
  - Laboratory Make-up: Both Types (Virtual>Physical) (Chini, 2010)

• Retention
  - Organizing information into a schema or the use of “organizers” improves retention. (Lawton & Wasanka, 1977; Moore & Readance, 1984)
Description of Current Study

- Conceptual based physics class for non-science majors.
- Traditional laboratory setting.

![Diagram showing physical and virtual components]

Virtual-Physical Sequence
- Pre-Test 1 & Confidence
- Virtual Experiment
- Post-Test 1 & Confidence

Physical-Virtual Sequence
- Pre-Test 2 & Confidence
- Physical Experiment
- Virtual Experiment
- Post-Test 2 & Confidence
Virtual Manipulative

CoMPASS Website
Changes from Previous Studies

**FALL 2009**

- **Week 1**
  - Pre-test
  - Mid-test
  - Post-test
  - 2 hours

**SPRING 2010**

- **Week 1**
  - Pre1
  - Post1
- **Week 2**
  - Pre2
  - Post2

- 2 hours

Assessment

- Twenty question multiple-choice conceptual test with short answer explanations on some questions.
  - Force questions: 8
  - Work/potential energy questions: 9
  - Mechanical advantage questions: 3
Assessment Example

Compare work to lift to same height if ignore friction.

A. Amy (using pulley system A) is doing more work
B. Bob (using pulley system B) is doing more work
C. Cathy (using pulley system C) is doing more work
D. The work done in all three situations is the same

Mixed ANOVA
main effect: p<.001
interaction: p<.001
Pre1 to Post1
interaction: p<.001
effect size: r=.41

Effect Size
small: r = 0.1-0.23
medium: r = 0.24-0.36
large: r > 0.37

Virtual-Physical (VP) steeper increase from Pre1 to Post1.
Mixed ANOVA

Main effect: p<.001
Interaction: p<.001

Pre1 to Post1
Interaction: p<.001
Effect size: r=.41

Post1 to Pre2
Interaction: p=.015
Effect size: r=.221

VP steeper decrease from Post1 to Pre2.

Total Score on Pulley Test

Physical-Virtual (PV) steeper increase from Pre2 to Post2
No difference in force test scores based on sequence of activities performed.
Mixed ANOVA
main effect: p<.001
interaction: p<.001
Pre1 to Post1
interaction: p<.001
effect size: r=.42

Work/Energy Sub-Score

VP steeper increase from Pre1 to Post1.

Mixed ANOVA
main effect: p<.001
interaction: p<.001
Pre1 to Post1
interaction: p=.052
effect size: r=.18

Post1 to Pre2
interaction: p<.001
effect size: r=.42

Work/Energy Sub-Score

Suggestive that VP makes steeper decrease from Post1 to Pre2.
Mixed ANOVA
main effect: p<.001
interaction: p<.001

Pre1 to Post1
interaction: p<.001
effect size: r=.42

Post1 to Pre2
interaction: p=.052
effect size: r=.18

Pre2 to Post2
interaction: p=.001
effect size: r=.308

Work/Energy Sub-Score

PV steeper increase from Pre2 to Post 2

Mixed ANOVA
main effect: p<.001
interaction: p<.001

Pre1 to Post1
interaction: p<.001
effect size: r=.42

Post1 to Pre2
interaction: p=.052
effect size: r=.18

Pre2 to Post2
interaction: p=.001
effect size: r=.308

Pre1 to Post2
interaction: p=.448
effect size: r=.07

No difference between PV and VP sequence from Pre1 to Post2.
Confidence

Q1. Low confidence 1 2 3 4 5 High

Confidence

No difference in confidence based on sequence

Confidence Rating All Questions

Differences in Forgetting

• Hypothesis 1: Organization of information offered by different manipulative leads to different retention level.
  - Virtual more organized but showed less retention.

• Hypothesis 2: Students have “intuitive” ideas which are temporarily changed at the end of week 1 but resurface at the beginning of week 2.
  - Analyzing explanations to test questions to determine if this is true.
Conclusion

- No difference in overall total score based on sequence (Pre1 to Post2).
- Work score supported better by virtual experiment, regardless of sequence.
- Force score supported equally well by each sequence.
- More ‘forgetting’ from Post1 to Pre2 for VP sequence.
- Confidence changed similarly for each sequence.

Thank you.

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