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

Adrian Carmichael, N. Sanjay Rebello
Kansas State University
Jacquelyn Chini
University of Central Florida
Elizabeth Gire
University of Memphis
Sadhana Puntambekar
University of Wisconsin, Madison

This work is funded in part by U.S. Department of Education, Institute of Education Sciences, Award # R305A080507

Kansas State University
Physics Education Research

1

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?

Kansas State University
Physics Education Research

2

Previous Research

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

  Simulation > Physical

- Simulations and physical equipment may offer equal support. (Triona, Klahr & Williams, 2007; Zacharia & Constantinou, 2008, Zacharia & Olympiou, 2011)

  Simulation = Physical

- Our previous study on pulleys (Gire et al., 2010):
  - Physical manipulatives and physical-virtual sequence offered better support for learning about force.

    Physical > Simulation for Force
  - Virtual manipulatives offered better support for learning about work.

    Simulation > Physical for Work

3

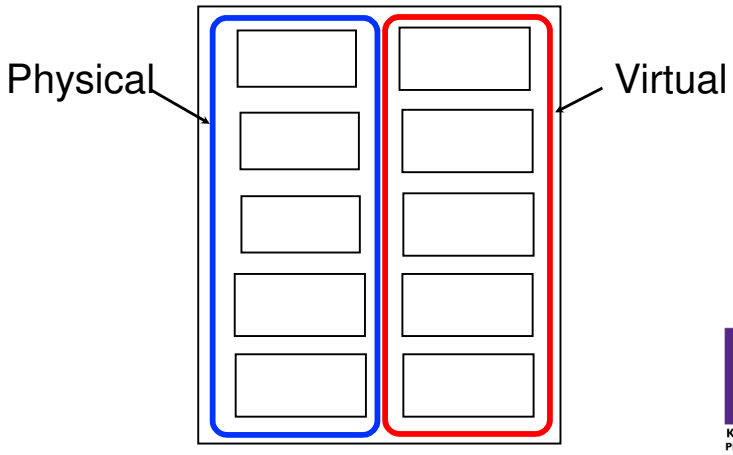
Previous Research

- 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)

4

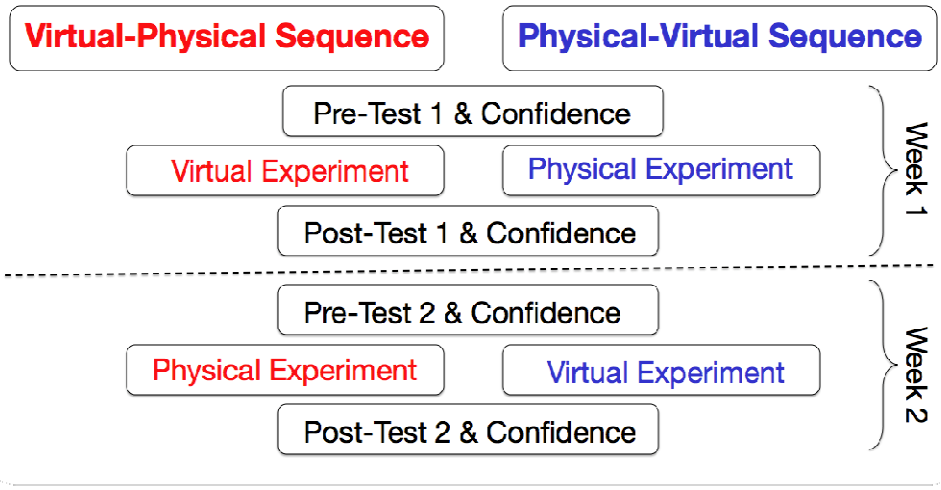
Description of Current Study

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



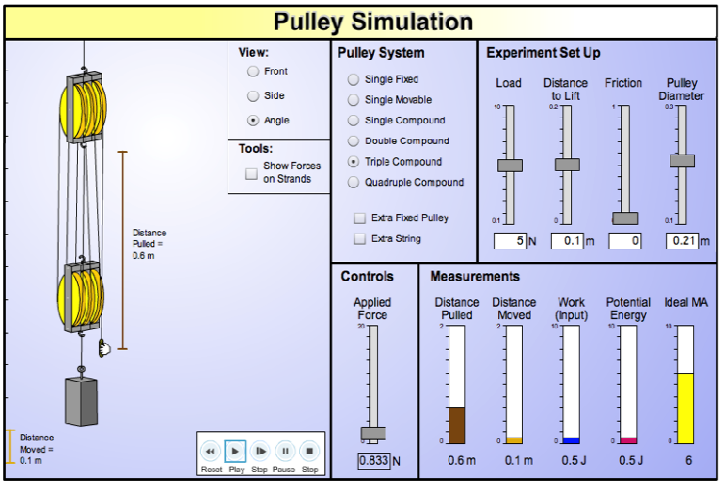
5

Description of Current Study



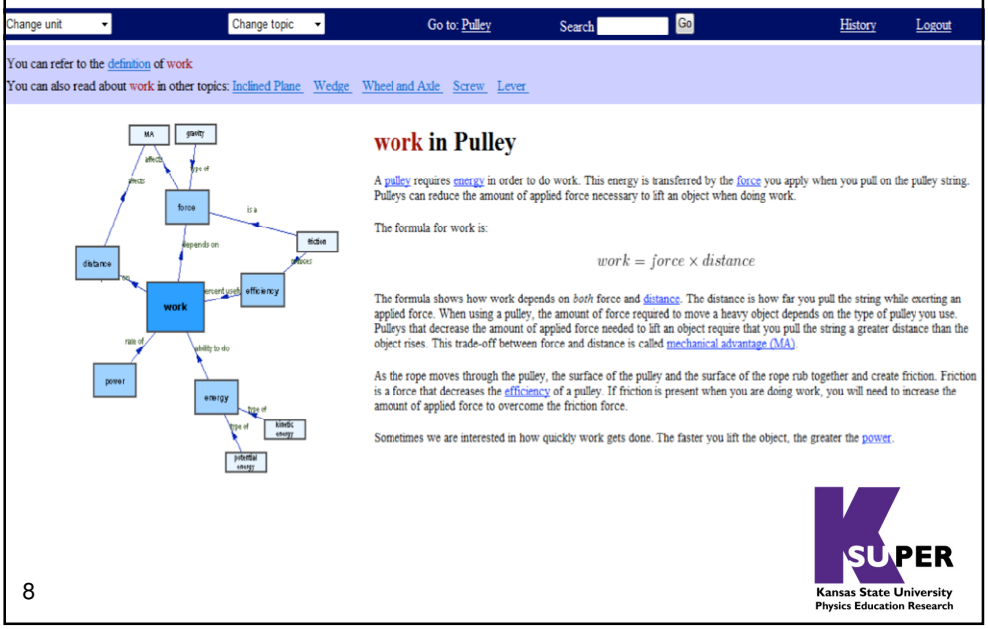
6

Virtual Manipulative



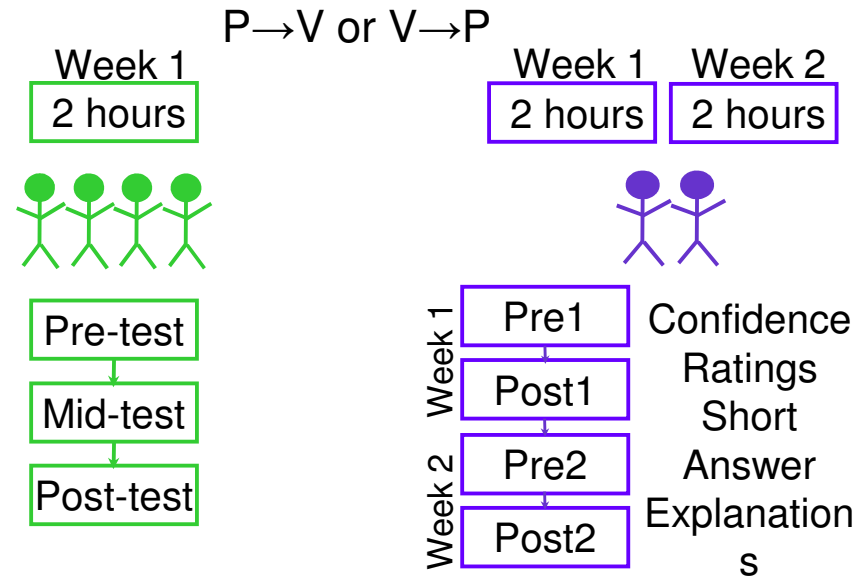
7

CoMPASS Website



8

Changes from Previous Studies



9

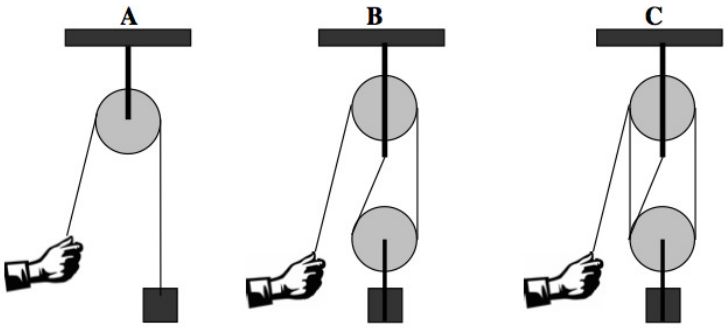
Assessment

- 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

10

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

11

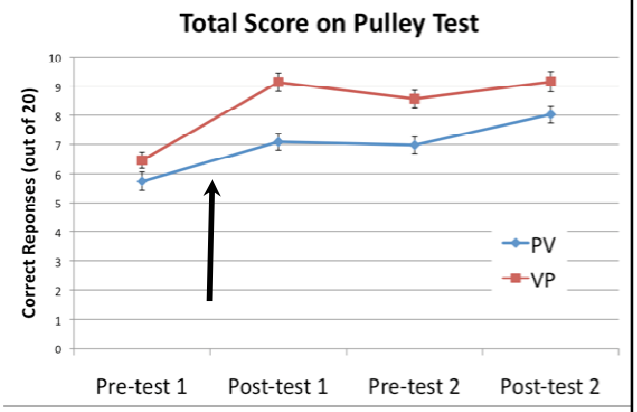
Kansas State University Physics Education Research

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

Total Score



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

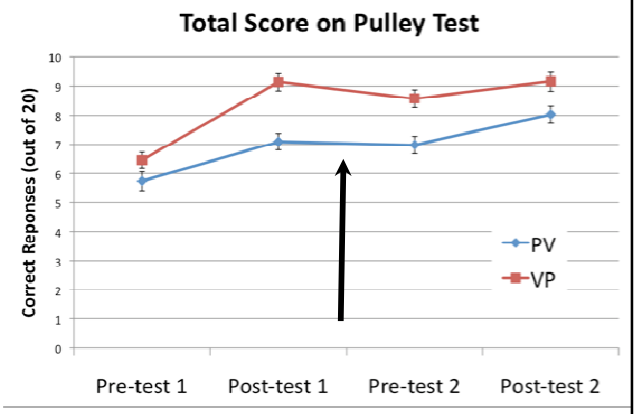
12

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

Total Score



VP steeper decrease from Post1 to Pre2.

13

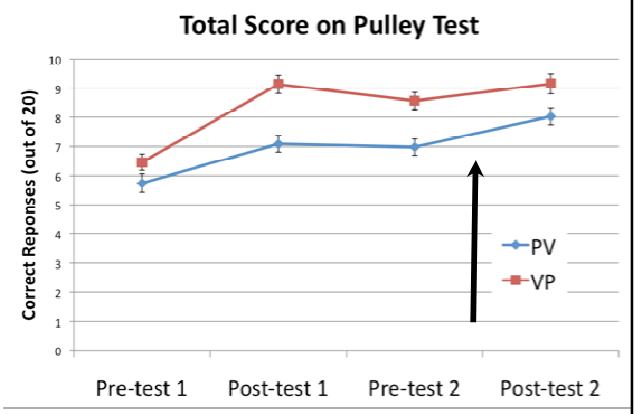
Mixed ANOVA
main effect:
p<.001
interaction: p<.001

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

Post1 to Pre2
interaction: p=.015
effect size: r=.221

Pre2 to Post2
interaction: p=.014
effect size: r=.22

Total Score



Physical-Virtual (PV) steeper increase from Pre2 to Post 2

14

Total Score

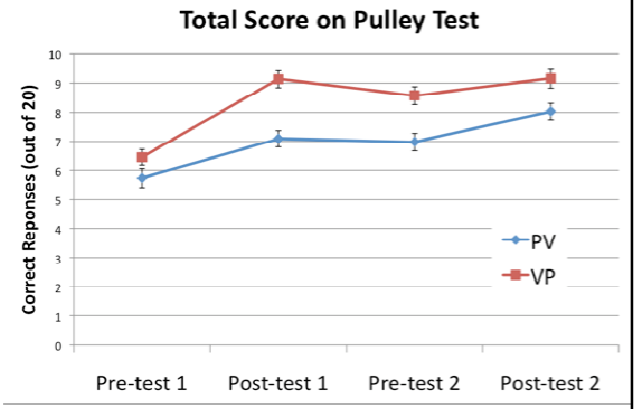
Mixed ANOVA
main effect: p<.001
interaction: p<.001

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

Post1 to Pre2
interaction: p=.015
effect size: r=.221

Pre2 to Post2
interaction: p=.014
effect size: r=.22

Pre1 to Post2
interaction: p=.706
effect size: r=.09

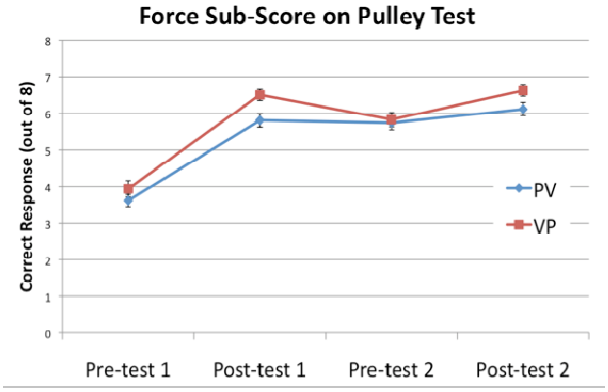


No difference between PV and VP from Pre1 to Post2.

15

Force Sub-Score

Mixed ANOVA
main effect: p<.001
interaction: p<.136



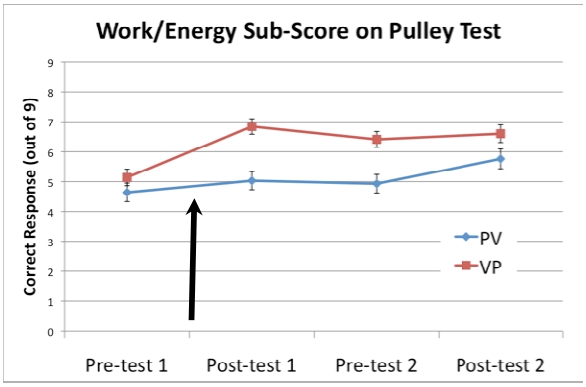
No difference in force test scores based on sequence of activities performed.

16

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.

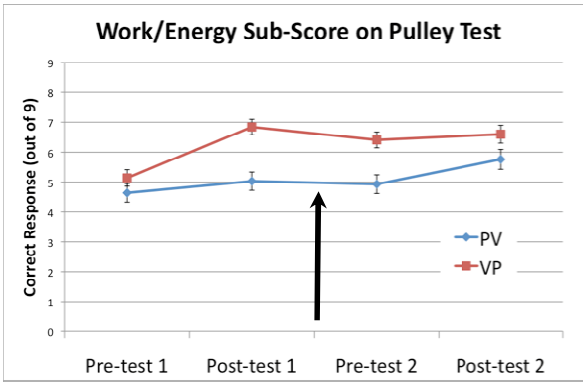
17

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

Work/Energy Sub-Score



Suggestive that VP makes steeper decrease from Post1 to Pre2.

18

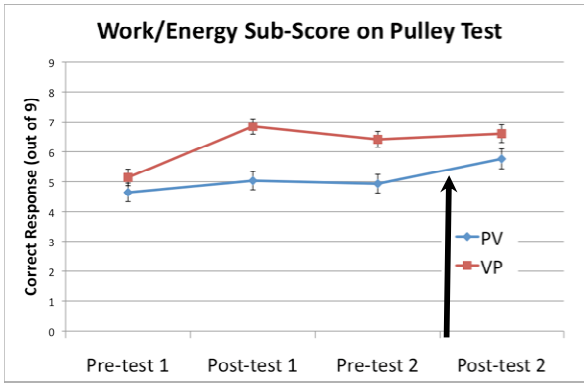
Work/Energy Sub-Score

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



PV steeper increase from Pre2 to Post 2

19

Work/Energy Sub-Score

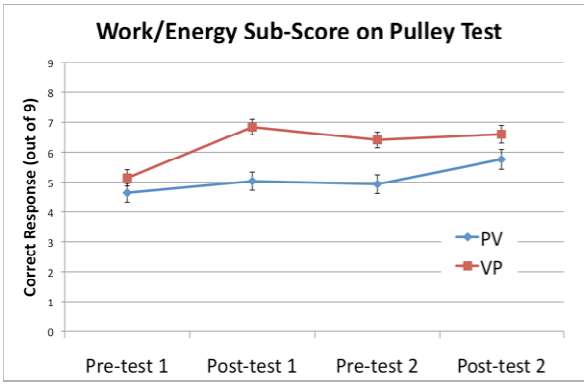
Mixed ANOVA
main effect:
p<.001
interaction: p<.001

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



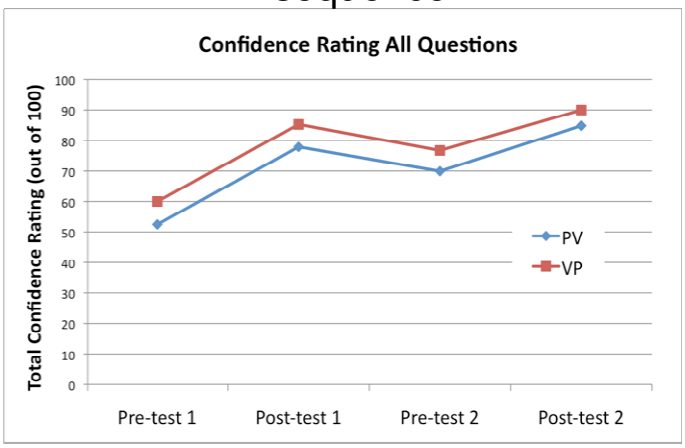
No difference between PV and VP sequence from Pre1 to Post2.

20

Confidence

Q1. Low confidence 1 2 3 4 5 High Confidence

No difference in confidence based on sequence



21

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.

KSUPER
Kansas State University
Physics Education Research

22

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 se

23

Kansas State University
Physics Education Research

Thank you.

adrianc@phys.ksu.edu
srebello@phys.ksu.edu

Kansas State University
Physics Education Research