

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

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**Kansas State University**  
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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?



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## 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

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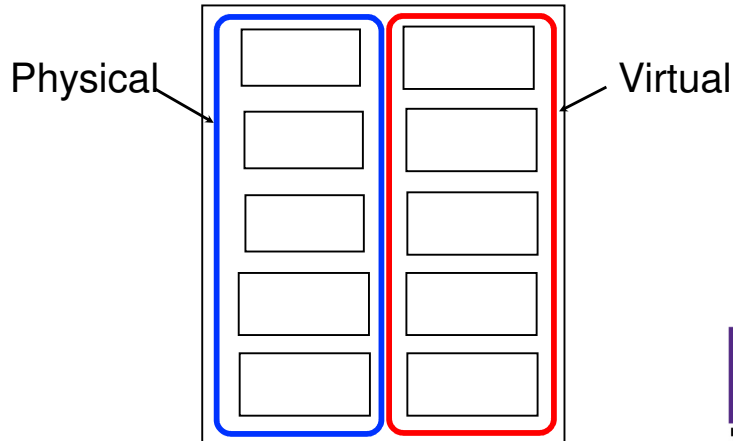
## Previous Research

- 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)

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# Description of Current Study

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



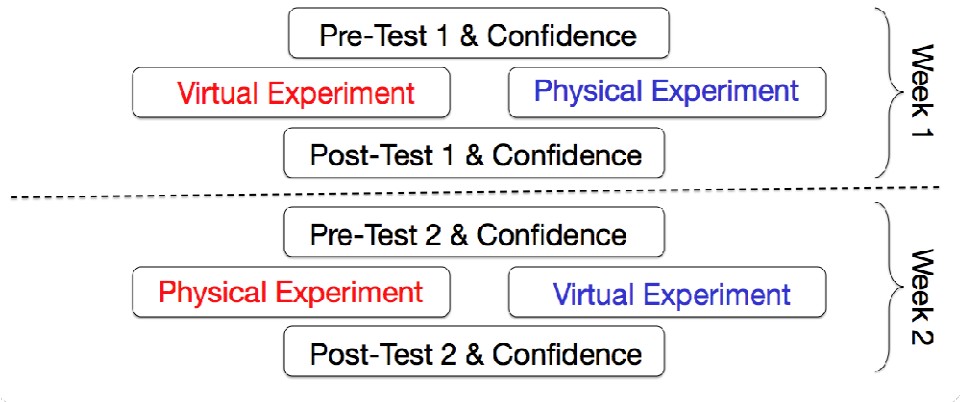
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# Description of Current Study

**Virtual-Physical Sequence**

**Physical-Virtual Sequence**



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# Virtual Manipulative

### Pulley Simulation

**View:**

Front

Side

Angle

**Tools:**

Show Forces on Strands

**Pulley System**

Single Fixed

Single Movable

Single Compound

Double Compound

Triple Compound

Quadruple Compound

Extra Fixed Pulley

Extra String

**Experiment Set Up**

Load: 5 N

Distance to Lift: 0.1 m

Friction: 0

Pulley Diameter: 0.21 m

**Controls**

Applied Force: 0.333 N

**Measurements**

Distance Pulled: 0.6 m

Distance Moved: 0.1 m

Work (Input): 0.5 J

Potential Energy: 0.5 J

Ideal MA: 6

**Measurements:**

Distance Pulled

Distance Moved

Work (Input)

Work (Output)

Potential Energy

Ideal MA

Actual MA

Efficiency

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# CoMPASS Website

Change unit | Change topic | Go to: Pulley | Search | Go | History | Logout

You can refer to the [definition of work](#)

You can also read about [work](#) in other topics: [Inclined Plane](#) [Wedge](#) [Wheel and Axle](#) [Screw](#) [Lever](#)

### 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:

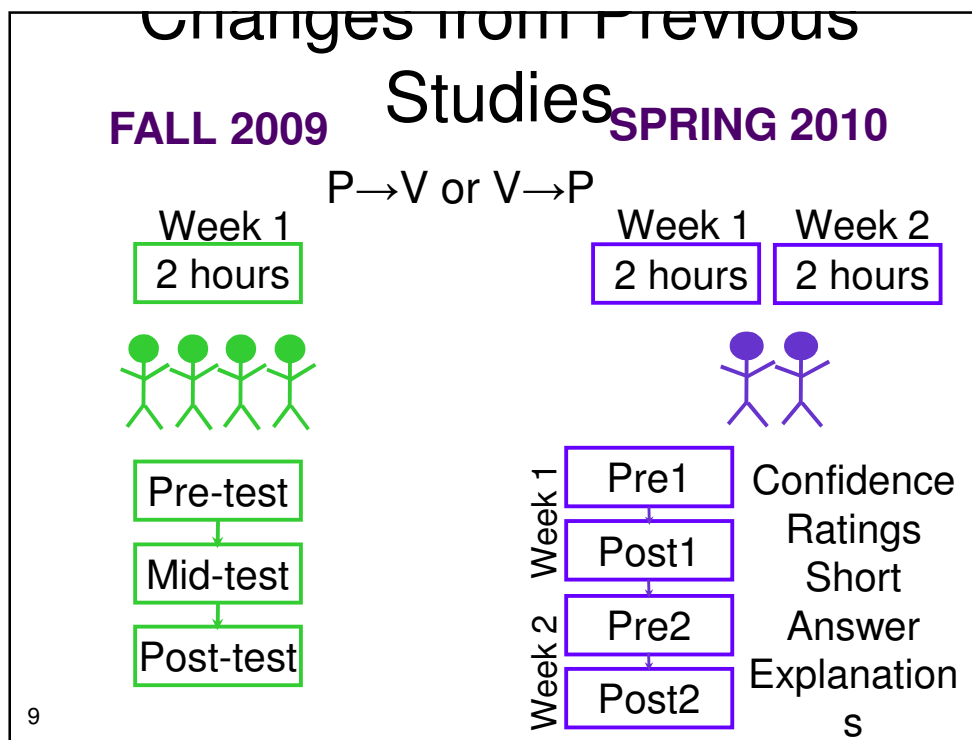
$$work = force \times distance$$

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 lift 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 \(MA\)](#).

As the rope moves through the [pulley](#), the surface of the pulley and the surface of the rope rub together and create friction. Friction is a force that decreases the [efficiency](#) of a pulley. If friction is present when you are doing work, you will need to increase the amount of applied force to overcome the friction force.

Sometimes we are interested in how quickly work gets done. The faster you lift the object, the greater the [power](#).

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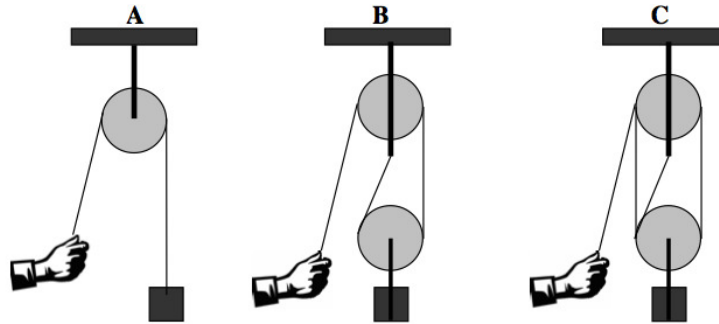


## Assessment

- 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

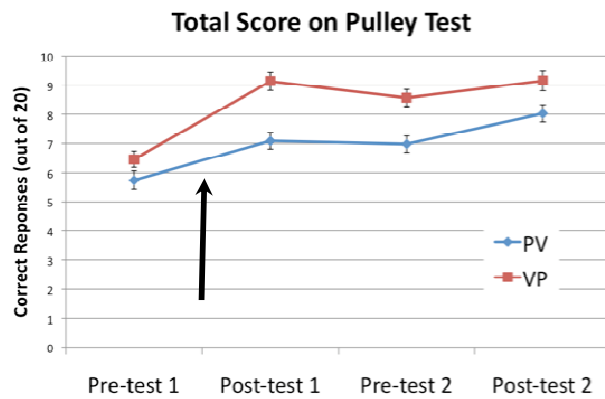


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**Mixed ANOVA**  
 main effect:  
 $p < .001$   
 Interaction:  $p < .001$   
**Pre1 to Post1**  
 interaction:  $p < .001$   
 effect size:  $r = .41$

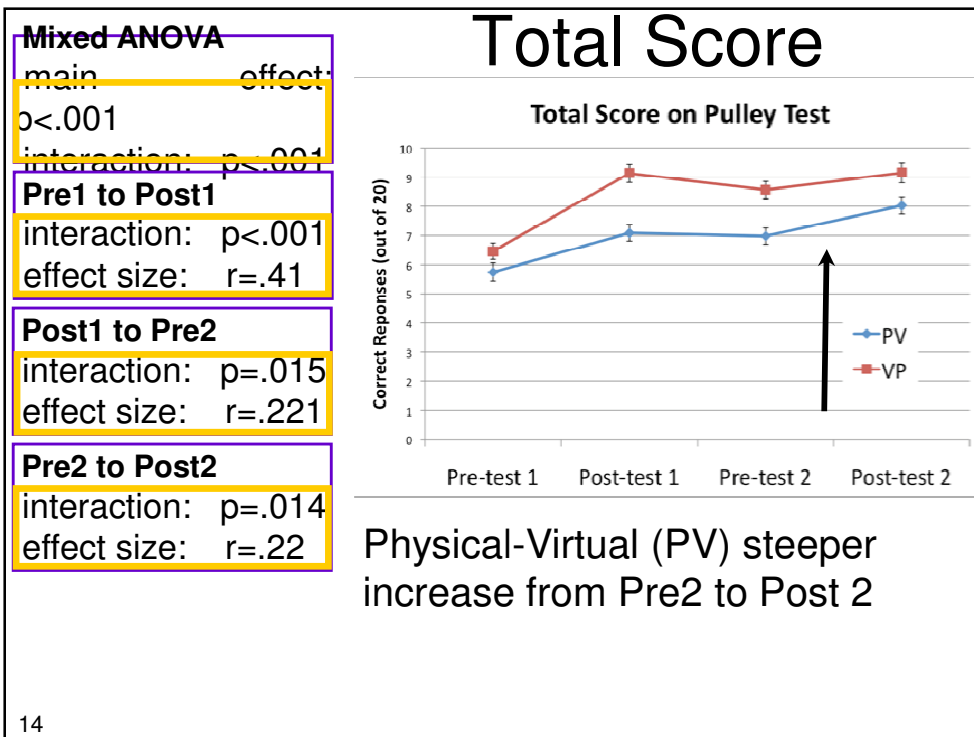
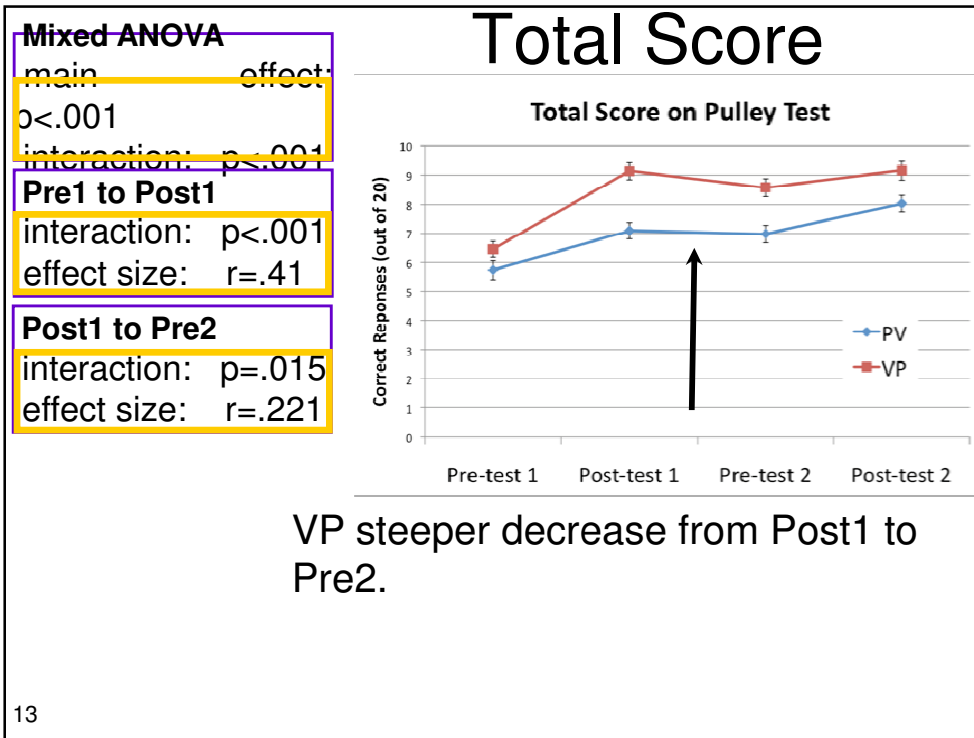
**Effect Size**  
 small:  $r = 0.1-0.23$   
 medium:  $r = 0.24-0.36$   
 large:  $r > 0.37$

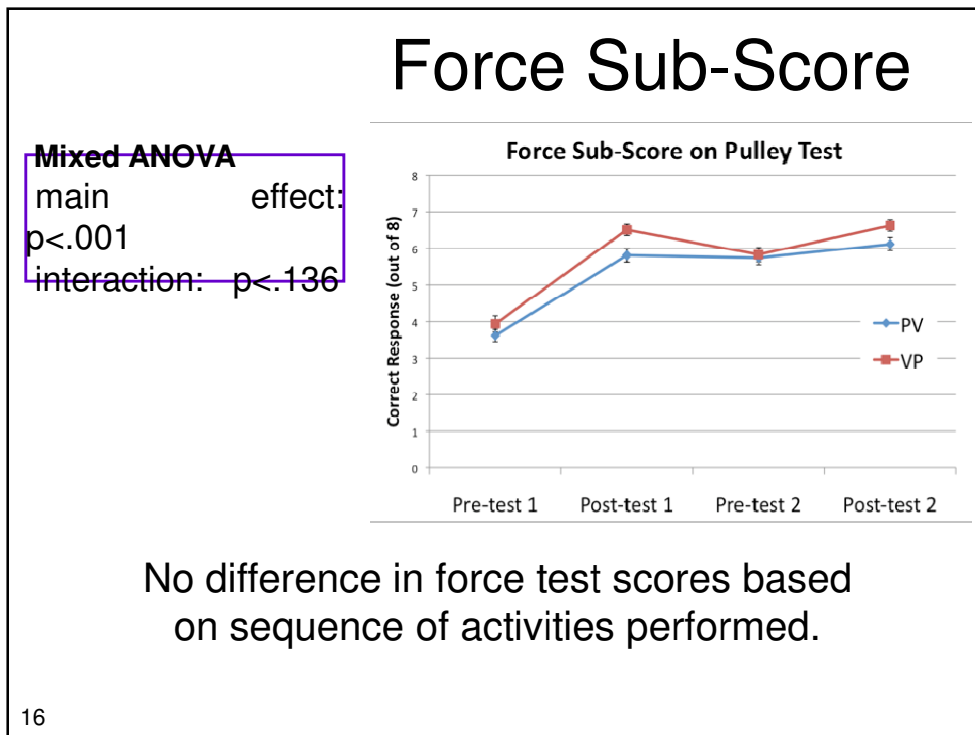
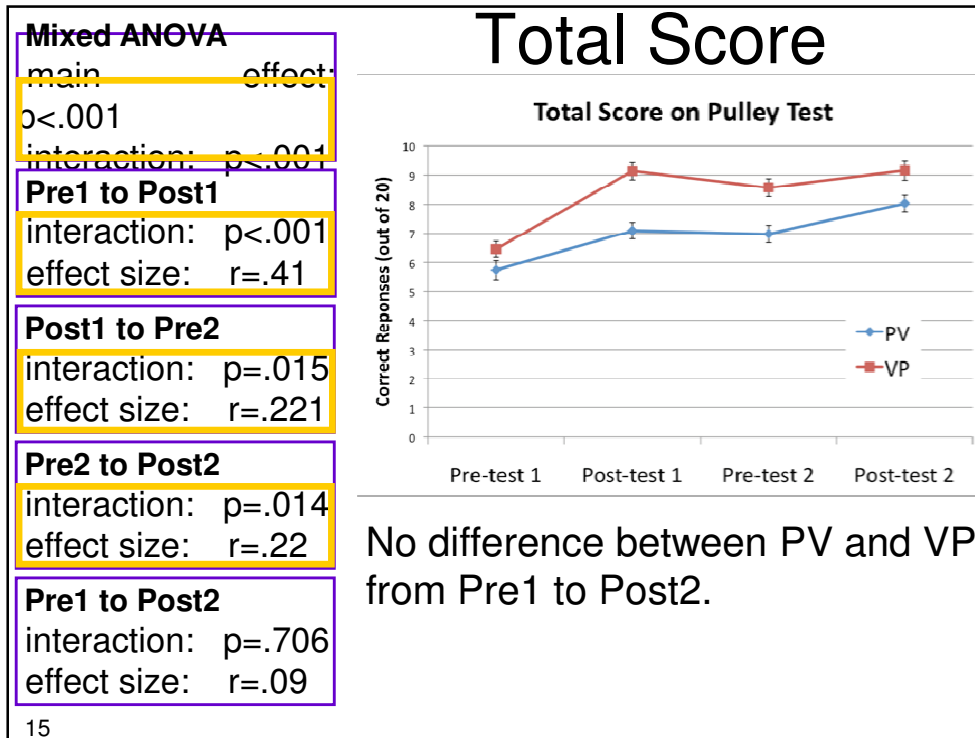
## Total Score



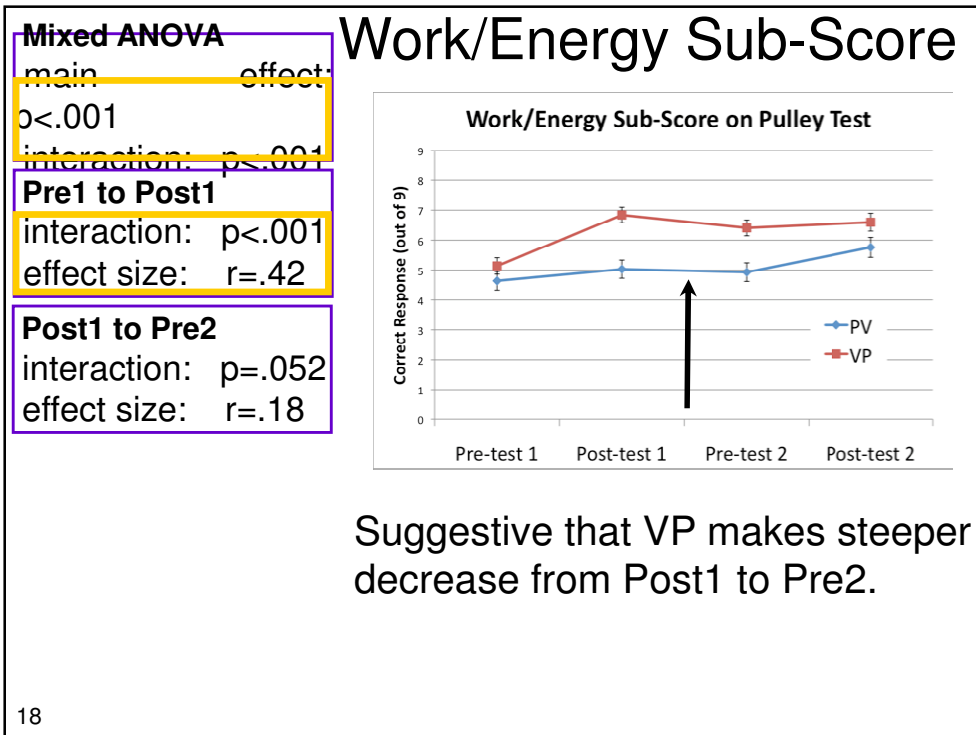
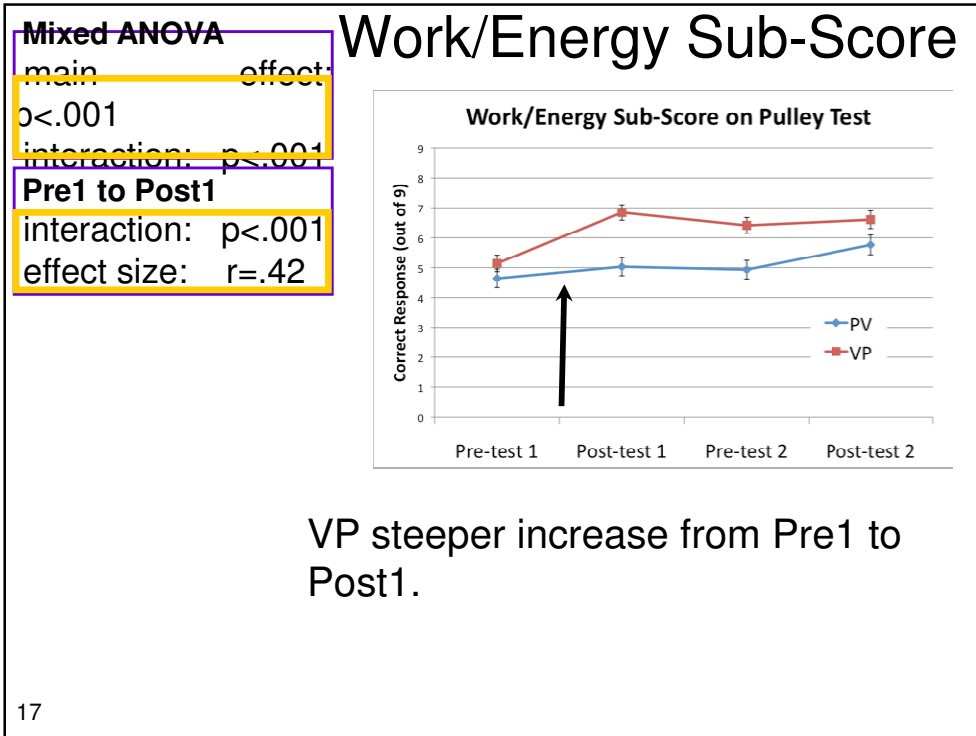
Virtual-Physical (VP) steeper increase from Pre1 to Post1.

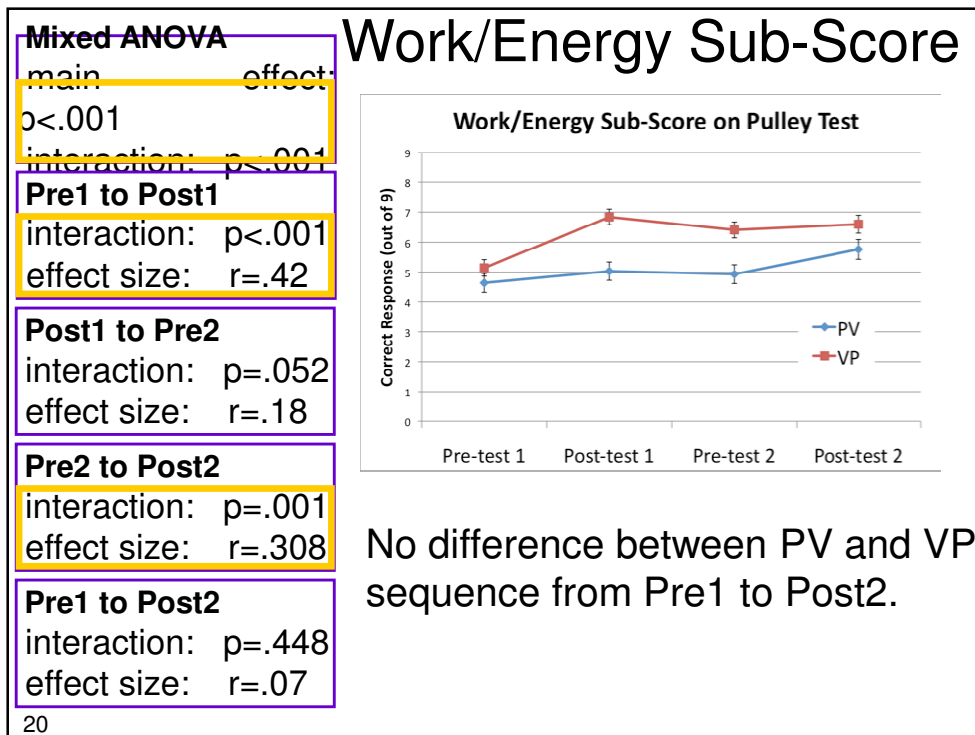
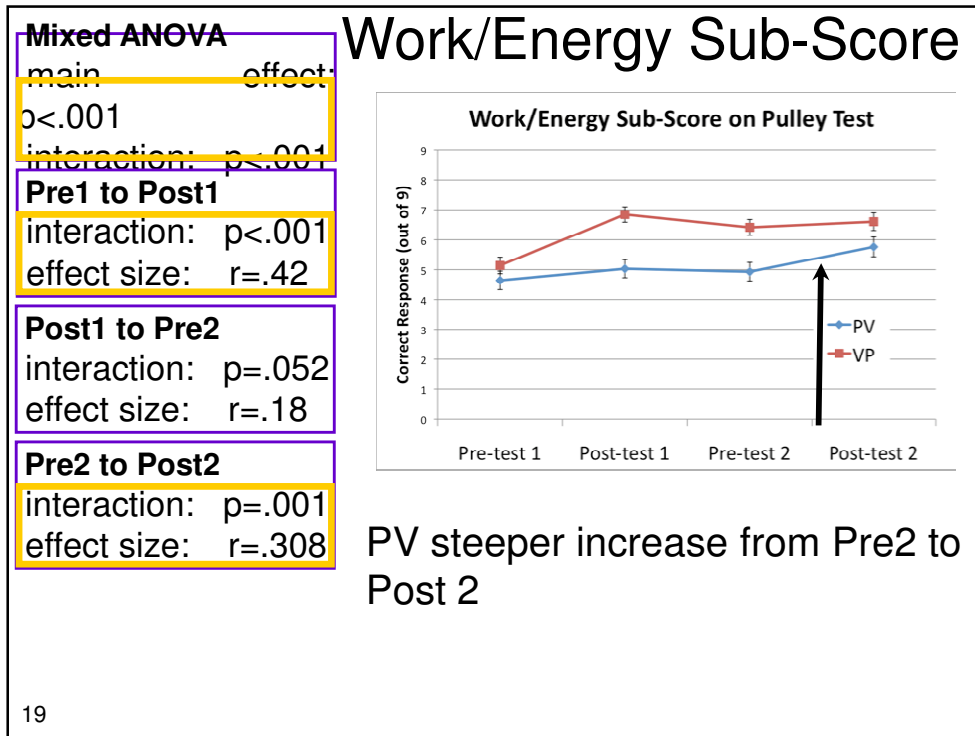
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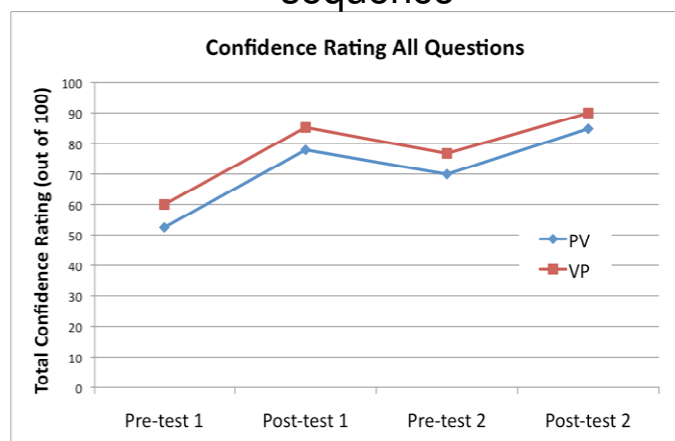


# Confidence

Q1. Low confidence                      1 2 3 4 5                      High

Confidence

No difference in confidence based on  
sequence



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## 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.

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## 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

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## Thank you.

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