

Introductory College Students' Views on the Usefulness, Value for Learning and Trustworthiness of Physical & Virtual Manipulatives

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Abstract

Our previous research on the effects of physical and virtual experimentation on student learning suggests a mode-dependent difference by concept. Here we examine whether students' views of the data collected from experiments with physical and virtual manipulatives follow the same trend. Students enrolled in an introductory conceptual-based college physics laboratory performed experiments with physical and virtual pulleys over two weeks. Students then completed an open-ended survey designed to explore their views about data collected from both manipulatives. We present our findings about which type of data students found more useful in various situations, which they felt better supported their learning, and which they found more trustworthy. We discuss the implications on students' learning of science with physical and virtual manipulatives.

Background

- Simulations can be more affordable, safer and more accessible than physical experiments
- Studies on student learning with physical and virtual manipulatives show mixed results (e.g. Zacharia, Olympiou & Papaevripidou, 2008; Zacharia & Constantinou, 2008)
- Our research (Gire, *et al.* 2010) shows that different sequences of physical and virtual manipulatives do not equally support student learning

Epistemology

- Includes and individual's beliefs about *what* knowledge is, *how* something is known, how knowledge is *evaluated*, and the *source* of knowledge (Hofer, 2001)
- May affect how students evaluate new knowledge and choose between discrepant events, e.g. ideas developed from experimenting with physical and virtual manipulatives
- Hammer & Elby (2002) describe the form as **epistemic resources** which are activated in a particular context

Research Questions

How do students perceive learning experiences supported by physical and virtual manipulatives after engaging in each?

- Which do they perceive as **more useful** in various contexts?
- Which do they perceive as **better supporting their learning**?
- Which do they perceive as **more trustworthy**?

Participants

- Students (N = 134) enrolled in a conceptual-based physics laboratory at a large Midwestern U.S. university
- Non-science majors
- Many did not take physics in high school
- Students may or may not be enrolled in the lecture section of the course

Data Sources

- Survey questions that varied context (rental store, exam or missed laboratory), physical quantity (force or work) and pulley system (fixed & movable or movable & double compound) to explore whether students thought the *physical or virtual manipulative* would be more useful in that situation
- Survey questions about which manipulative students *trusted more* and which they felt helped them *learn better*

Context of Study

- CoMPASS (Concepted Map Project-based Activity Scaffolding System) pulley curriculum (Puntambekar, *et al.*, 2003). See Figure 1.
- Students used *physical* (Figure 2) *then virtual* (Figure 3) **or virtual then physical** manipulatives to create various pulley systems and measure or calculated physical quantities, including *force*, *work*, *mechanical advantage* and *potential energy*

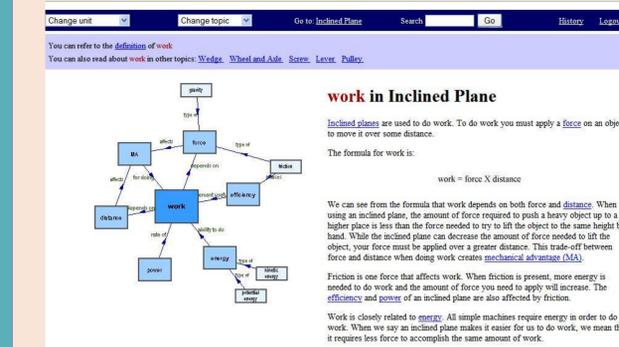


Figure 1. Online hypertext system. Students select a concept by clicking on it in the concept map or as a hypertext link in the text. Used before the activities to explore science concepts.

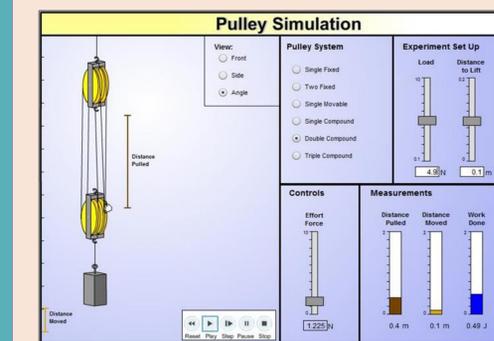


Figure 2. Physical pulleys. Students build and string pulley systems by hand. They use a spring scale to measure force and a meter stick to measure distance.



Figure 3. Pulley simulation. Students select a pulley system and adjust the load, distance lifted and effort force with sliders. The load is lifted and the distances and work are dynamically displayed.

Survey Questions

Question	Context	Variable	Pulleys
Rental-A	Rental Store	Not specified	Fixed & Movable
Rental-B	Rental Store	Not specified	Movable & Double Compound
Test-A	Exam	Force	Fixed & Movable
Test-B	Exam	Work	Fixed & Movable
Test-C	Exam	Force	Movable & Double Compound
Test-D	Exam	Work	Movable & Double Compound
Make Up-A	Missed Lab	Force	Not specified
Make Up-B	Missed Lab	Work	Not specified

- **Trust:** "If you could only analyze data from one of the activities– the experiments with real pulleys or the computer simulation of pulleys– which do you think you would **trust more**?"
- **Learn:** "If you were only going to do one pulley activity– the experiments with real pulleys or the computer simulation of pulleys– which do you think would **help you learn best**?"
- You need to rent a pulley system to help lift an oversized dresser tot hr secodn floor balcony of your home. An employee at your local rental store informs you they have several pulleys you can rent. To help you decide which pulley to rent, she offers to let you try out either *real toy pulleys* OR a *computer simulation of pulleys*. At the rental store, you have to choose between a **fixed pulley** and a **movable pulley** to help you lift the bed. What would you try out to help you make your decision?

Results

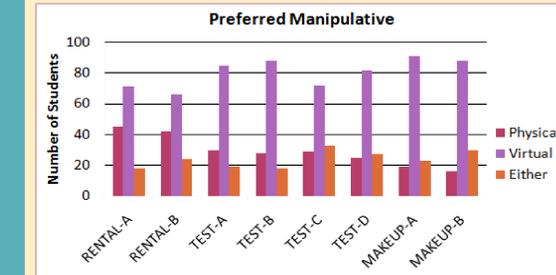


Figure 4. Manipulative judged as more useful for situations described in preceding chart. Chi-square goodness of fit test was significant at $p < .001$ for all questions.

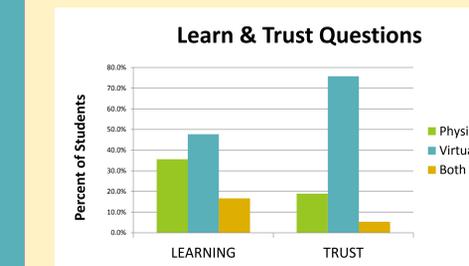


Figure 8. Manipulative judged as better for learning or more trustworthy.

Reasoning Analysis, Figures 9-12: We analyzed the open-ended responses students provided for their choices to the learning & trust questions. The responses fell into the following categories.

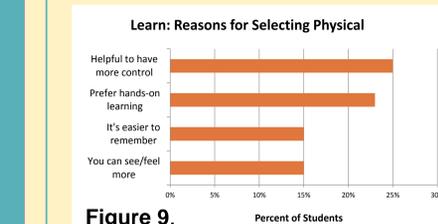


Figure 9.

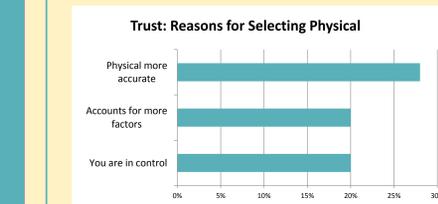


Figure 11.

Switching Answers, Figures 5-7: We analyzed the survey results to see if students were more likely to change their selection of the most useful manipulative if the *context*, *concept*, or *pulley systems* were changed.

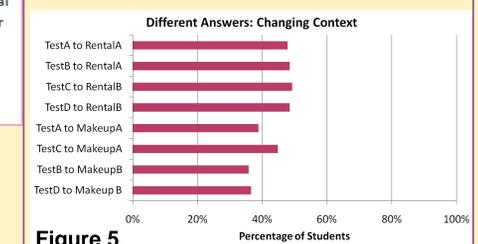


Figure 5.

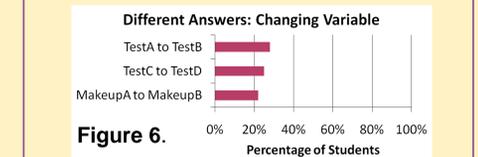


Figure 6.

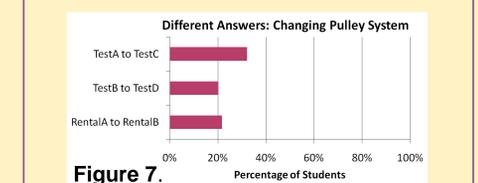


Figure 7.

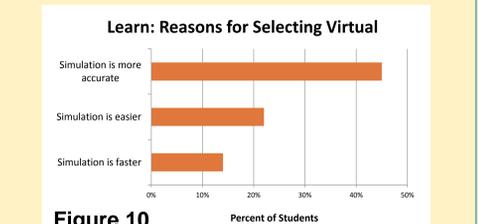


Figure 10.

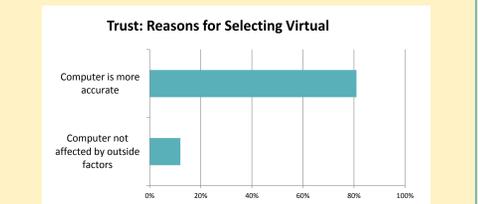


Figure 12.

Conclusions

- Students view virtual manipulative as most useful in all contexts. Although our prior research indicates students' learning about different topics (i.e. force and work) is better supported by different manipulatives, students responses did not follow this pattern. The activation of their epistemic resources seems to be more closely tied to the questions *context*.
- Comparing students' reasoning reveals a difference in opinion about whether it is better to include or exclude *frictional effects* in the experiments.
- Further study could explore whether the extent to which students believe the physical or virtual manipulatives are useful mediates the time and effort they invest in their learning, thus influencing *what* students learn from each manipulative.