

Comparing the Effects of Physical and Virtual Experimentation Sequence on Students' Understanding of Mechanics



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OBJECTIVE

Investigate how the order of using physical and virtual manipulatives affects students' understanding of physics concepts underlying pulleys.

ABSTRACT

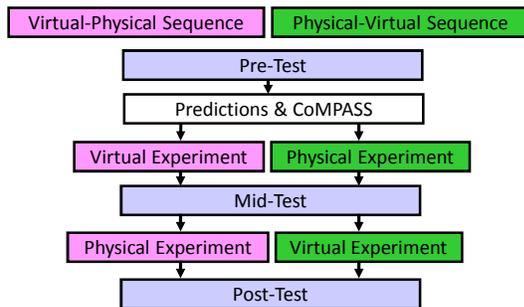
This study aims to understand how the sequence of physical and virtual activities affects student conceptual understanding of pulleys. We compared pre-, mid- and post-test scores of two treatment groups, which differed by the temporal order in which the physical and virtual activities were completed. We examined overall scores as well as scores on individual questions. In questions dealing with the concept of work, students who performed the virtual experiment first seemed to have blocked information learned in the physical. In questions about force, students in each treatment group showed similar gains from pre- to mid-test but from mid- to post-test there was no gain, consistent with the primacy effect. Further, students who performed the physical experiment first did better on force mid-test questions, consistent with advantages of kinesthetic learning.

INTRODUCTION

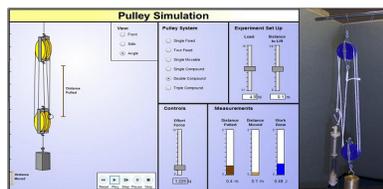
- Previous Research:** Virtual manipulatives (computer simulation) as effective as physical manipulatives (real experiment) in supporting student learning under some conditions. [1-4]
- This Research:** Use both manipulatives, but change the order in which physical and virtual manipulatives are used.
- Theory:** Blocking [5], Primacy Effect
 - Blocking:** Learners presented with two cues in a sequence respond to the first cue over the second because the latter is either disregarded or deemed unnecessary. Blocking can be affected by the relative salience of cues.
 - Primacy:** Learning dominated by first in a series of learning experiences. Familiarity, personal significance of material promotes primacy effect.

METHOD

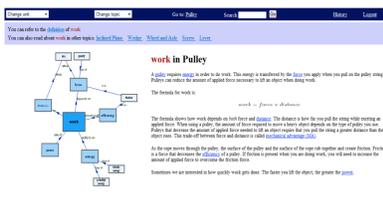
- Context:** Conceptual Physics Lab, Non-science majors.
- Curriculum:** CoMPASS: Design-based, integrates concept maps & hypertext prior to physical or virtual experiments.
- Data:** Pre-, mid- and post-test scores: overall & question subsets.



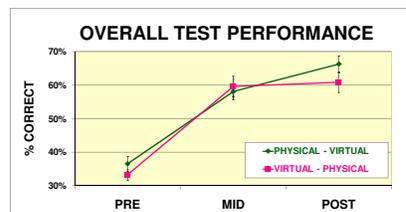
Computer simulation used for virtual experiment (left) and sample pulley setup used in physical experiment (right).



CoMPASS (Concept Mapped Project-based Activity Scaffolding System) hypertext environment with clickable "fish eye" concept maps and textual descriptions of concepts related to simple machines.

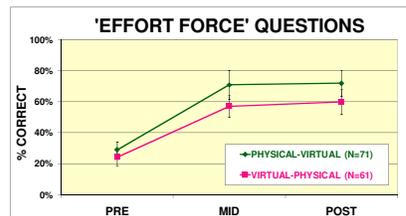


RESULTS

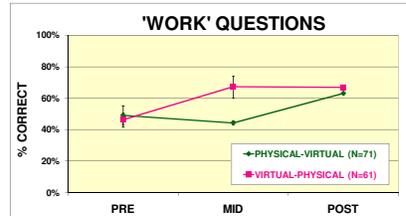


No statistically significant difference between the PV and VP sequences at the $\alpha=.05$ level.
Significant difference between the mid- and post-test scores in the PV sequence only.

Scores by Concept Tested



PV sequence showed a significant gain in score between pre- and mid-test. No change for either sequence between mid- and post-test.



VP sequence: significant gain in score from pre- to mid-test, no change from mid- to post test.
PV sequence: no change between pre- and mid-test, significant gain in score from mid- to post-test.

RESULTS

Test Scores by Concept Tested

'Effort Force' Concept

- Increase from pre- to mid-test for both PV and VP, but PV students scored higher on the mid-test.
- No change from mid- to post-test for both PV and VP.

'Work' Concept

- VP Sequence: Increase from pre- to mid-test, followed by no change from mid- to post-test, after using real pulleys.
- PV Sequence: No change from pre- to mid-test, followed by significant mid- to post-test increase, after using simulation.

DISCUSSION & CONCLUSIONS

'Effort Force' Concept

- Concept is equally salient in virtual and physical experiments, so blocking occurred equally in both sequences. Neither sequence is preferred based on saliency.
- Primacy effect observed in both sequences. Consistent with notion that familiarity induces primacy effects. 'Effort Force' is a familiar concept to students.
- PV group scored higher than VP group on 'Effort Force' questions. May be due to kinesthetic learning advantages provided by physical experiment. Important for the physical experiment to occur first to prevent blocking.

'Work' Concept

- Virtual experiment provided high salience for 'Work' concept using a dynamically increasing bar chart.
- VP Sequence: This high salience may have blocked further learning from the physical activity.
- PV Sequence: No evidence of blocking -- Consistent with blocking reduced if the second cue is more salient than first.

REFERENCES

- De Jong, T. & Van Joolingen W.R. (1998) Scientific Discovery Learning With Computer Simulations of Conceptual Domains, *Review of Educational Research*, 68, 179-201.
- Finkelstein, N. D., Adams, W. K., Keller, C. J., Kohl, P. B., Kohl, K. K., Podolsky, N.S., et al. (2005). When learning about the real world is better done virtually: A study of substituting simulations for laboratory equipment. *Physical Review Special Topics- Physics Education Research*, 1, 010103.
- Klahr, D., Triona, L. M., & Williams, C. (2007). Hands on what? The relative effectiveness of physical versus virtual materials in an engineering design project by middle school children. *Journal of Res. in Science Teaching*, 44(1), 183-203.
- Zacharia, Z. C. & Constantinou, C. P. (2008). Comparing the influence of physical and virtual manipulatives in the context of the Physics by Inquiry curriculum: The case of undergraduate students' conceptual understanding of heat and temperature. *American Journal of Physics*, 76(4&5), 425-430.
- Denton, S.E. & Kruschke, J.K. (2006) Attention and salience in associative blocking. *Learning & Behavior*, 34(3), 285-304.