

Investigating Change and Consistency in Introductory College Students' Understanding about Pulleys

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MOTIVATION

- Constructivist theory implies active learner engagement, but does not require students to use physical manipulatives (Triona & Klahr, 2003)
- Preliminary research: No statistically significant difference on tests scores between students using physical, virtual manipulatives

But, does the manipulative used affect student reasoning and consistency in using this reasoning?

THEORETICAL PERSPECTIVE

Resources (Hammer, 2000)

- Small grain-sized knowledge elements which may be unstable
- Reasoning can be seen as the activation of resources

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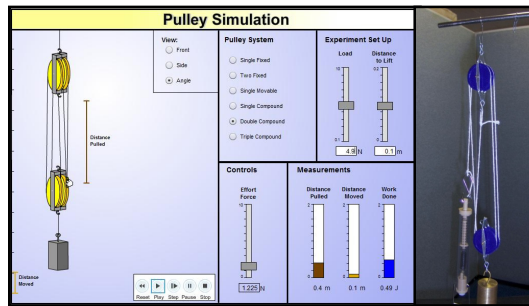
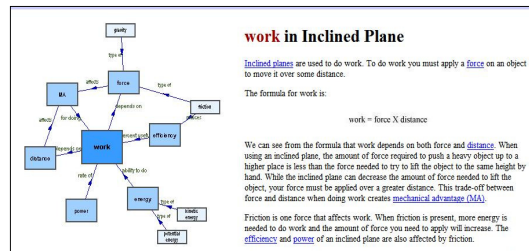
RESEARCH QUESTIONS

- How do the reasoning resources that students activate change from before to after they complete an activity using physical or virtual manipulatives?
- How does the context of the question used to probe student reasoning influence the resources a student might activate?

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CONTEXT OF STUDY

- CoPASS :
Concept Map
Project-based
Activity Scaffolding
System
(Puntambekar &
Stylianou, 2003)
- Pulley Unit:
Physical & Virtual
manipulatives



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METHODOLOGY

- Participants (N = 12)
 - Introductory algebra-based physics
 - Life science majors
- Research Design
 - Pre-Test
 - Semi-structured Interview
 - Brainstorming & Exploring CoPASS website
 - Activity (Physical OR Virtual) & Written Discussion Q's
 - Post-Test
 - Semi-structured Interview

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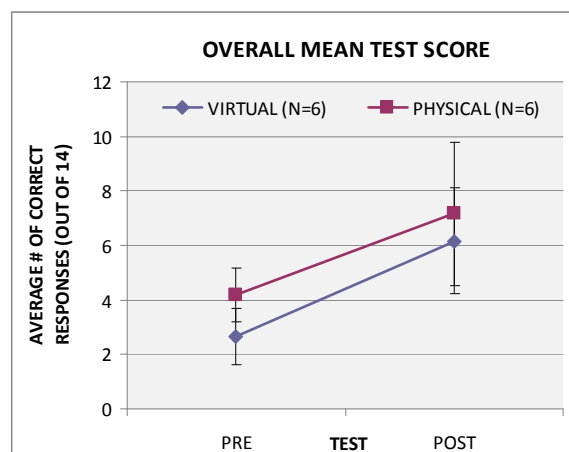
SOURCES OF DATA

- Pre/Post-Tests
 - Questions: Multiple-choice, conceptual
 - Purpose: Assess changes in conceptual understanding
- Semi-Structured Interview
 - Questions:
 - Same concept, different context as test questions
 - Open-ended format
 - Purpose: To learn about...
 - Reasoning resources
 - Consistency in reasoning compared to test questions

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RESULTS – OVERALL SCORES

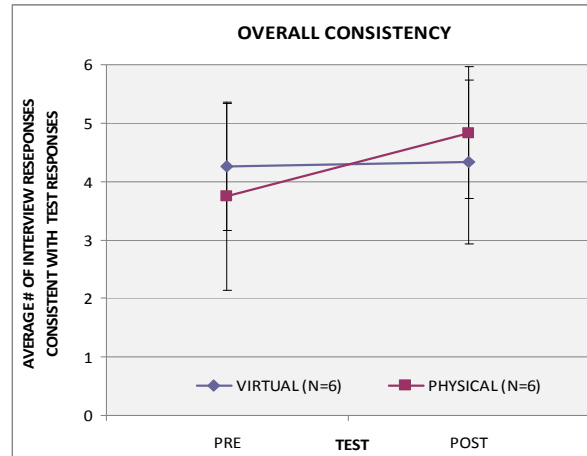
- Both physical and virtual groups improve from pre to post
- No significant difference in pre-to-post improvement between groups



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RESULTS – OVERALL CONSISTENCY

- Physical group:
Pre to post
Increase in
consistency
- Virtual group:
No significant
increase in
consistency from
pre to post



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QUESTION 8 – TEST RESULTS

Concept: Increased height results in increased work needed to lift

Test Question

Jacob is using a fixed pulley to separately lift two boards of the exact size and mass up to two different heights. He lifts one board 10 meters and then lifts the second board 20 meters.

When lifting the board 20 meters, Jacob is doing _____ work as/than when lifting the first board 10 meters high?

- A) more B) less
C) Same D) Insufficient info

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QUESTION 8 – TEST RESULTS

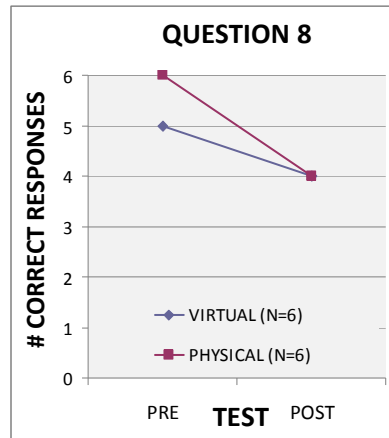
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QUESTION 8 – INTERVIEW RESULTS

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Interview Question

You and your friend have just purchased identical mattresses and use the same pulley to lift them into your rooms. You live on the third floor, and your friend lives on the sixth floor.

How does the amount of work you do lifting the mattress compare to the amount of work your friend does?

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Results

Pre-Interview

- 3/6 consistent with test question response
- Used physical intuition, correctly answered question

Post-Interview

- 5/6 consistent with test question response
- Suppress the 'physical intuition' resource
- Used resources acquired from activity, sometimes inappropriately

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"The force I use to get [the mattress] to the third floor is going be more than [the work needed] for [the sixth floor] because [the sixth floor] has the ability to spread the work ... over a greater distance."

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Results

Pre-Interview

“I’m trying to think back over this experiment... [the objects] all [get lifted to] the same distance but the distance pulled is different... I think I would be doing less work being on the sixth floor.”

- resp
- Success the ‘physical intuition’ resource
- Used resources acquired from activity, sometimes inappropriately

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QUESTION 9 – TEST RESULTS

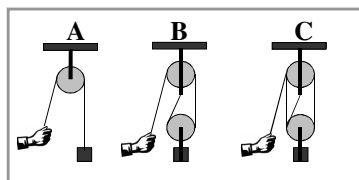
Concept: Pulley does not change the work needed to lift object

Test Question

Alice uses pulley A, Brenda uses B, and Carl uses C to lift the same load.

What can you say about the work done by each of them?

- A) Alice does more work
- B) Brenda does more work
- C) Carl does more work
- D) All do same work



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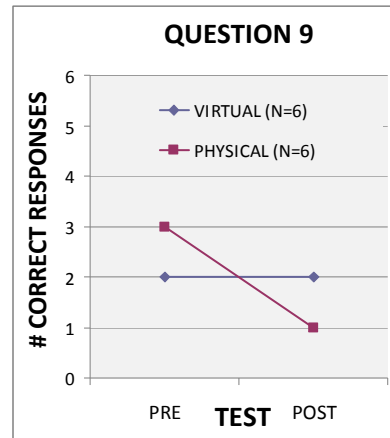
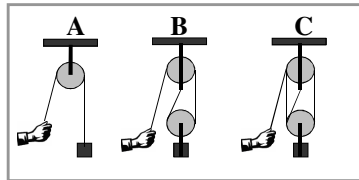
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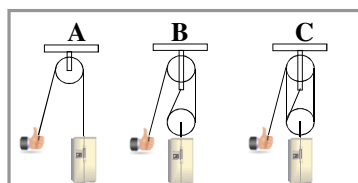
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Concept: Pulley does not change the work needed to lift object

Interview Question

You and two of your friends buy the same refrigerator and use the same pickup truck to move it. You use pulley A to lift the fridge into the truck. Betty used pulley B, and Carl used pulley C.

What can you say about the work being done by each of you?



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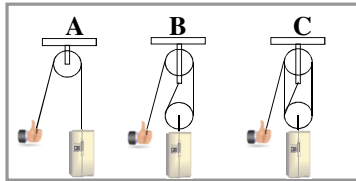
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Results

Consistency

- Pre- & Post-Test: 4/6 consistent between test & interview

Pre-Interview

- Surface features focus:
 - A more work b/c fewer pulleys
 - C least work b/c more rope twisted

Post-Interview

- Physical: Mechanistic reasoning (Hung & Jonassen, 2006)
- Virtual: Covariational reasoning

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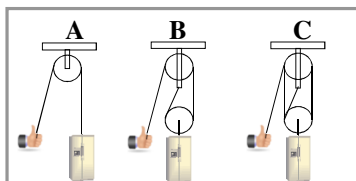
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Results

“Although pulley C would have more friction... it’s easier to move an object with... a double [compound pulley]... because you’re pulling more distance, but the weight is distributed more.”

- – C least work b/c more rope twisted

Post-Interview

- Physical: Mechanistic reasoning (Hung & Jonassen, 2006)
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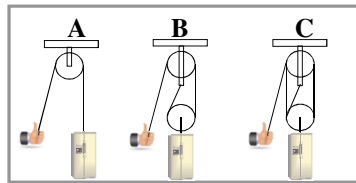
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QUESTION 13 – TEST RESULTS

Concept: Work done to lift object equals change in potential energy

Test Question

You use a movable pulley to lift a watermelon to your tree house.

How does the work you do lifting the watermelon compare to its potential energy once lifted?

- The work is more than the potential energy
- The work is less than the potential energy
- The work and potential energy are the same
- Not enough information

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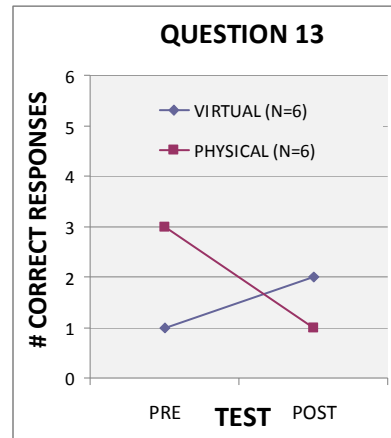
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QUESTION 13 – INTERVIEW RESULTS

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Interview Question

Because the elevator in your dorm is too small, you decide to use a movable pulley to lift a futon into your room.

How does the work done to lift the futon compare to its potential energy once it is lifted?

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Results

Consistency

- Context (watermelon vs. futon) mattered
- Pre : 3/6 consistent with test response.
- Post: 2/6 consistent with test response.
- Most common interview responses given were not choices on the test.

Pre-Interviews

- Unfamiliar with potential energy.

Post-Interviews

- Physical: Refer to covariation observed between Work & Potential Energy
- Virtual: Refer to equality observed between Work & Potential Energy

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"I don't really know how [work & PE] relate...[but] as one increases, so does the other."

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- Physical: Refer to covariation observed between Work & Potential Energy
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“It has to be the same. You have to put the same amount of work to lift the object as... the amount of potential energy it has.”

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CONCLUSIONS

RQ1) How do reasoning resources activated by students change after they complete an activity?

- Overall, Increase in correct responses shows students' activation of productive resources improves after activity
 - Are more likely to suspend physical intuition leading to incorrect response on some questions
- In the post-interviews, students tended to utilize resources activated by the experiment they performed.
 - Physical: Used either mechanistic or covariational reasoning depending upon the situation
 - Virtual: Consistently used covariational reasoning.

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CONCLUSIONS

RQ2) How does the context of the question influence the resources a student might activate?

- Overall, the number of consistent responses increased from the pre- to post-test interview
 - ‘Guessing’ resource is suppressed by resources acquired from doing the activity
- Increase in consistency from pre- to post-test interview does not imply increase in correctness
 - Could be due to the activation of unproductive resources during the experiment, whether physical or virtual

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Thank You

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