# Effect of Argumentation Scaffolds on Student Performance on Conceptual Physics Problems

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## INTRODUCTION

- Argumentation is a key skill used to logically make decisions and solve problems [1-4].
- Bing and Redish [5] investigated warrants used to argue about physics problems using mathematics.
- No studies regarding argumentation on conceptual physics problems requiring qualitative reasoning.

## **RESEARCH QUESTIONS**

- What level of argumentation and conceptual quality do our participants demonstrate on physics problems?
- How does the level of argumentation and conceptual quality change based upon prompts designed to scaffold the construction and

#### **CONSTRUCT PROBLEM EXAMPLE** Two kids that you are babysitting are playing with spring loaded toy cars that can bounce off • What evidence each other. Ryan picks up a truck and Sam picks up a car that is lighter than the truck. They push them against each other in the center of the living room on the wooden floor ready to let go. Before to support their they do that, you ask:

#### PROMPTS CONSTRUCT EVALUATE What is your answer? Which statement do you Construct an argument to agree with? Or do you justify your answer. have another argument? Remember to consider: Explain your answer. Remember to consider: • What evidence supports supports your answer? One of your classmates your selection? may disagree with you. • Explain your reasons for What might their not choosing the alternative be? alternative. • How might a classmate • What reasons would your classmate provide supporting the other

**EXAMPLE PROBLEM WITH PROMPTS** 

#### EVALUATE PROBLEM EXAMPLE

Kids you are babysitting play with spring loaded toy cars that bounce off each other. Ryan picks up a truck and Sam a car that is lighter than the truck. They push them against each other in the center of the living room ready to let go. Just then, you ask: "Which one will get to reach the wall on their side faster?"

Ryan: "They get there at same time, we are start from the middle of the room, the walls are equally far, so it takes the same time to get to walls." Sam: "Your heavier truck is slower than my lighter car, so my car gets to the wall sooner than your truck."

evaluation of arguments?

## THEORETICAL BACKGROUND

**Toulmin's Argumentation Pattern** (TAP) [6] describes the elements of an argument: claim, data, warrants, backing, and rebuttals.

## METHODOLOGY Data Collection

- Five conceptual homework problems adapted from literature, administered online in three conditions.
- N = 246 participants in 1<sup>st</sup> semester calculus-based physics at a public U.S. Midwestern university.
- All students completed FMCE, based on score and gender, they were divided into three groups.
- Each of the three groups were assigned a condition:
  - **Construct** Provided 'construct' prompted probs.
  - Evaluate Provided 'evaluate' prompted probs.
  - **Control** Provided problems with no prompts.

"Which one will get to reach the wall on their side faster?"

 conclusion?
 What would you reply to classmate to explain your position is right?

your preferred solution?
What would you reply to your classmate to explain your position is right?

solution disagree with

#### **CONTROL PROBLEM EXAMPLE**

Two kids that you are babysitting are playing with spring loaded toy cars that can bounce off each other. Ryan picks up a truck and Sam picks up a car that is lighter than the truck. They push them against each other in the center of the living room on the wooden floor ready to let go. Before they do that, you ask: "Which one will get to reach the wall on their side faster?" What is the answer? Explain your reasoning.



- MANOVA: Statistically significant difference among the conditions [Wilks' Λ= 0.640, F(20.0, 390.0) = 4.875, p < .001, η2 = 0.20] for all five problems.
- Univariate ANOVAs : Statistically significant (p<0.05) differences b/w conditions in argumentation scores on all problems, conceptual scores for two of five problems.
- Follow up Tukey's : Statistically

#### Data Analysis

- Argumentation Quality: Rubric adapted from Sadler
   & Fowler [7], based on TAP Toulmin's TAP [6].
- **Conceptual** Quality: Designed separate rubric to account for scientific correctness of answer and reasoning.

ARGUMENTATION	CONCEPTUAL
QUALITY	QUALITY
1: No grounds	0: Incorrect answer with
2: Single grounds	no justification
2. Multiplo groupde	1: Incorrect with partly
5. Multiple grounds	correct justification
4: Single/Multiple grounds,	2: Correct answer, partly
with counter-position	correct or no
5: Single/Multiple grounds,	justification
with counter-position	3: Correct answer with
and rebuttal	correct justification

**Argumentation Quality** 

#### **Conceptual Quality**

significantly (p < 0.05) greater argumentation scores for construct and evaluate conditions compared to the control condition for four problems, no significant differences between construct and evaluate conditions.

### CONCLUSIONS

- 1. On average participants who did not receive any prompts were unable to create arguments with more than a single ground for justification. For the most part these students are able to answer the problem correctly, but are only able to provide partly correct reasoning.
- 2. When argumentation prompts are provided, there is a statistically significant increase in argumentation quality for both the construct and evaluate conditions. Participants on average are able to provide a justification with multiple grounds.

Study demonstrates that typical statements such as "explain your reasoning" may not produce higher argumentation quality unless students are appropriately guided to provide justifications.

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