

Title: Tracking the referent system to understand students' math modeling processes

Authors: Christopher Webster, Benjamin M. Zwickl

School of Physics and Astronomy, Rochester Institute of Technology

Understanding the system that students are focused on while modeling helps to explain their decisions in the modeling process.

ACTIVITY DETAILS

Activity gave students a common kinematics problem:
 "A zookeeper is trying to hit a monkey out of a tree with a dart gun. If the monkey will let go immediately as the dart is fired, should the zookeeper aim above, below, or directly at the monkey?"

- After they made a prediction, they were shown a video demonstrating the answer (aim directly at it)
- They verified the answer with math
- Then given an apparatus and told to adjust the math model based on their experience

ROLE OF AN APPARATUS

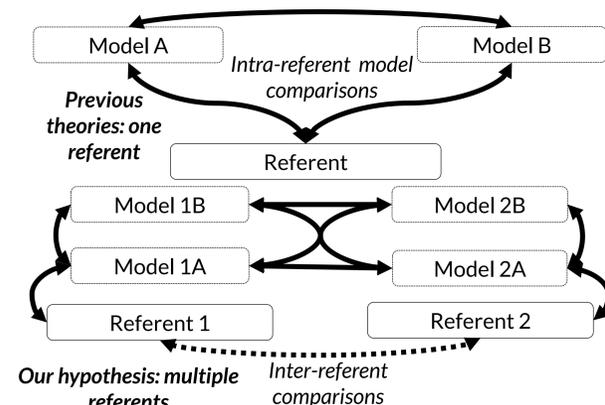
- Reveals concepts to students that they haven't considered, like that the dart's initial velocity is irrelevant:

A: "Well, we found that it was independent of velocity, right?"

B: "Yeah, that's uh, that's actually weird."

- In addition, an apparatus focused the students' attention on the most important discrepancies between their observations and previous predictions

CONCEPTUAL DIAGRAM:



INTRO

- Mathematical modeling is important for the classroom and industry
- Previous work on modeling assumes that there is only one referent system (dashed box in figure)
- We hypothesize that activities with multiple referents will complicate the modeling process (orange arrows in figure)

METHODS

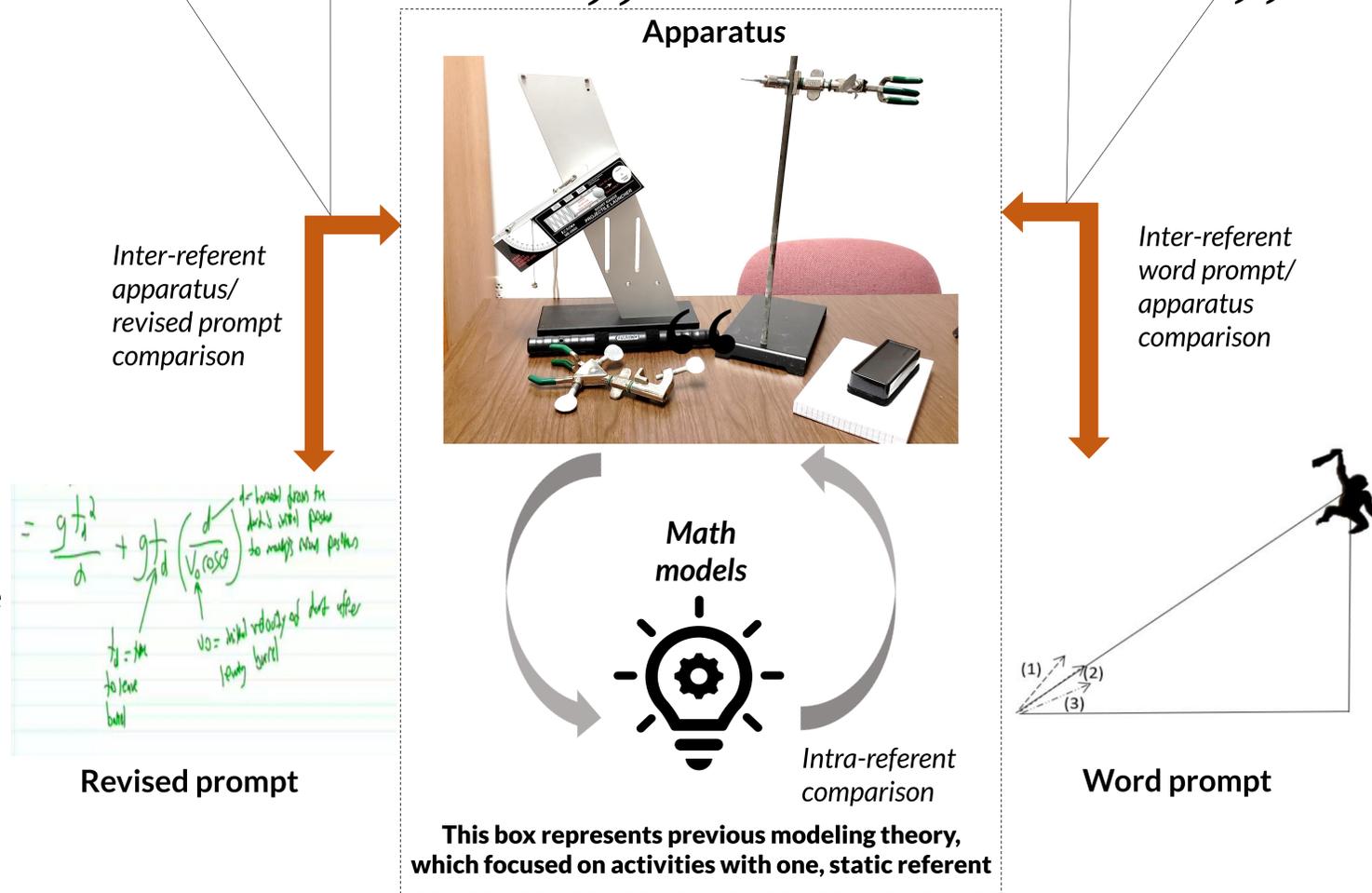
1. We designed an implemented a kinematics-based modeling activity with multiple representations of a single phenomenon
2. Recorded video, audio, and written data from 7 think-aloud interviews with 3rd- and 4th- year undergraduate STEM students
3. Used theory of epistemic games as a lens for qualitative analysis

KEY RESULTS

- "System focus" is not static; rather, it is fluid as students compare multiple model referents as they work
- In a modeling activity, students make comparisons not just between models of one referent, but also between different referents
- Activity design is important in shaping students' system focus

“ Well I think, I just think we were going about doing it not the **right way** those times in general. Like, we were, it was, I think there was just a lot more **uncertainty in how we were doing the experiment** in the first way. ”

“ The time it missed on us, it missed because I let go of this [the eraser] after the ball had already hit. Is that what you're talking about? 'Cause in that case **we're not modeling the same system anymore**...we assumed that both drop at $t = 0$. ”



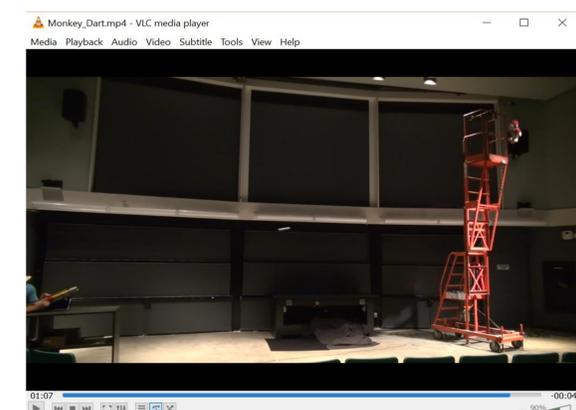
Revised prompt

$= \frac{g t^2}{2} + g t \left(\frac{d}{V_0 \cos \theta} \right)$

$t_1 = t_2$
to leave ball

$V_0 = \text{initial velocity of dart after launch}$

$d = \text{horizontal distance from the dart's initial position to monkey's initial position}$



Video