DEVELOPING KNOWLEDGE FOR TEACHING: THREE CASES OF PHYSICS GRADUATE STUDENTS

Brian W. Frank, Middle Tennessee State University, Department of Physics & Astronomy
Natasha M. Speer, University of Maine, Department of Mathematics & Statistics

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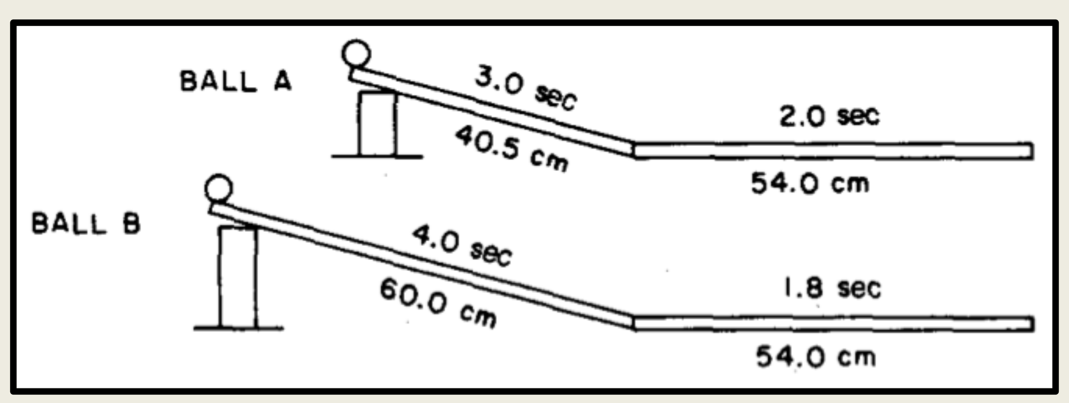
Research Focus

From research on mathematics and science teachers, it appears that particular types of knowledge used in teaching correlate with reform-oriented teaching practices and with student achievement [1, 2, 3]. Knowledge of student thinking, a subset of pedagogical content knowledge [4] has been found to play prominent roles in teachers' practices. Findings suggest that by engaging in the work of teaching, teachers acquire knowledge of how students think, but the education research community has not yet captured this learning as it occurs**. We sought to capture the genesis of various types of knowledge for physics teaching through task-based interviews** with physics graduate students as they **examined student solutions to physics problems.**

Data Collection & Analysis

- **Task-based interviews** with 7 graduate TAs as they examined & discussed student work drawn from PER literature [5,6]
- Interview protocol asks TAs to solve problems and provide reasoning, discuss what a person needs to know to solve the problems, **generate examples of student work, and examine & discuss prepared examples.**
- **Cross-case analysis** [7] informed by methods of fine-grained analysis of teacher knowledge [8,9] and student thinking

Ramp Problem: Comparing Acceleration



Adopted from Trowbridge & McDermott [6]

Correct Approach

$a = \Delta v/\Delta t$

$= 30$ cm/s / 4 s

$= 7.5$ cm/s/s

Common Student Approach

$v = x/t = 60/4 = 15$ cm/s

$a = v/t = 15/4 = 3.5$ cm/s/s

The approach results in a correct comparison, but the thinking behind it fails to distinguish **change in velocity** from **average velocity**.

References

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Jamie Develops New Knowledge of How Student Think

Jamie Generates an Example of Student Work

"So the first thing they might do is **they might say that, acceleration is meters per second squared…** And I'm gonna say, this one is 40.5 over 3 times 3. And this one is 60 over 4 times 4. So, then I'd say like, 'A' is greater acceleration."

Jamie Offers an Initially Broad and Vague *Diagnosis*

"[It] would mean that the student understands the units of acceleration, but that would be about it. He **doesn't understand how acceleration, velocity, distance, and time are inter-related**."

Jamie Later Develops a *Specific & Accurate Diagnosis*

"They are doing something different, **because they are not finding a final velocity, which you have to use.** They are finding an average velocity**… So this is what this student's approach doesn't understand: the difference between change in velocity and the average velocity.** What's missing from this student's understanding is that to find our acceleration, what we need is the change in velocity not the average velocity."

Sam Develops New Physics Content Knowledge Concerning Acceleration

Sam's Initially Thinks in Terms of Average Velocity

"The way I'd try to do it is **to compare their average velocity**. If they start from rest **and reach some average velocity, they are accelerating. …**This would be an average velocity of 13.5 and 15. **So then if they start from rest, and B reaches a greater average velocity, then I'd be tempted to say it's accelerating more."**

Sam Later Distinguishes Various Velocity Concepts

"So what we are interested to figure out is initial and final velocity. **And so, previously, I had thought you couldn't find final velocity, but the amount of time it takes to traverse this distance is the amount of velocity you get when you are finished accelerating**. So if you know the initial velocity, which we know, and you find the final velocity, then we know how **the change in velocity** worked. So I think that looking at it this way, looking at **the change in velocity** and the amount of time it takes. What I had left out. Or what I thought I couldn't find was final velocity, **and I just found some velocity. Which isn't quite right."**

Alex Makes Little Progress

Alex Constructs 'velocities' over 'time' Ratios

"This is my velocity down the ramp. And then I did the distance over the time for the straight part. And then. Let's see. I guess I did the average acceleration for the whole segment. I did the straight part minus the ramp and it took five seconds to go from here to here. That gave me 2.7 cm/s squared. **I guess that's my average acceleration for the whole time."**

Alex Applies This Same Idea to Student Work

"They took the ramp distance over the ramp time, and then they divided by the ramp time again to get centimeters per second. **So they did, acceleration is velocity over time, and they applied that. So they came up with some sort of average acceleration**."

Discussion of Cases

These cases illustrate the range of outcomes we observed during our investigations. Jamie demonstrated strong content knowledge which he made use of to investigate the meaning of student work. Along the way, **Jamie developed insights into student thinking** that he did not appear to know before the interview. Sam demonstrated gaps in his content understanding, but **developed new insights about that content** while attending to student work. Alex struggled with the problem, making use of the same problematic ideas to both solve the problem and interpret student work.

Conclusions and Implications

Ultimately we seek to understand how Jamie and Sam were able to learn something new through attending to student thinking. Based on our more extensive analyses, we hypothesize two specific processes that supported the development of new knowledge:

- For both Jamie and Sam**, the activity of interpreting student work elicited content knowledge that had not been put to use while solving the problem.**
- Jamie and **Sam developed specific and accurate interpretations of student thinking, which were then used as the basis for making more general claims.**

These and other findings can shed light on how teachers learn while engaged in the work of teaching and can also inform the design of professional development activities to support such learning in novice teachers.