The importance and challenges of attending and responding to students' thinking

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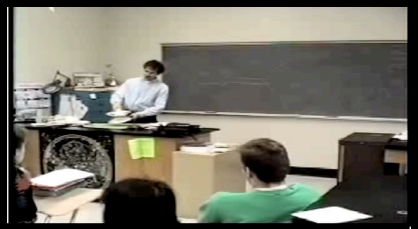
Discussing the "Marino Phenomenon"



Hammer, 1997

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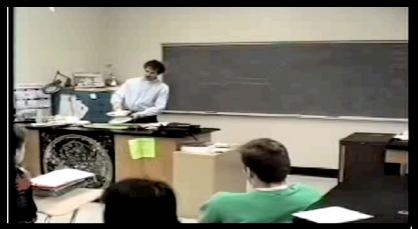

Hammer, 1997

A view of science

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- A pursuit: *Of coherent, mechanistic accounts of natural phenomena.*

  Coherent: Holding together, meaningfully connected and consistent

  Mechanistic: Based on reliable,familiar causes-and-effects

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  - *including the canon of accepted understandings, and*
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Erin: Um, I think because since you sucked out the air, it's like, it caves in because there's not any air so it has no, nothing's pushing it in from the inside to make it like squa, like -

College students working on a question: Estimate the difference in air pressure between the floor and the ceiling.

Tuminaro, 2004

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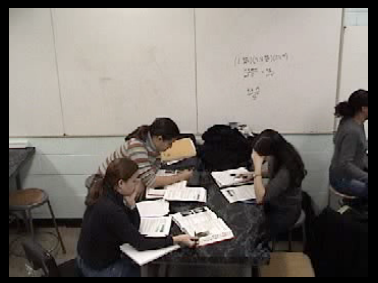

Tuminaro, 2004

Well-established findings

1. Children have extensive intellectual resources for learning science. (Duschl *et al*, 2007; many many studies!)
2. College students typically treat science as information to memorize.
(Hammer, 1994; Redish, Steinberg & Saul, 1998; many others)

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Why the second, given the first?

A likely conjecture

We assess ideas, and teach students to assess ideas, for alignment with the canon — the results of *scientists'* inquiries — rather than by the ideas' merits within the *students'* inquiries.

Students take up a different pursuit: Figuring out how to score points in the course = "get it right"

Sharon Fargason's third grade class

- 14 days of lesson (~ 1 hour / day)
- "Toy car module"—elicit beginnings of *energy*
- Launching question: *What ways could they think of to get a toy car to move?*
- Spawns many other questions

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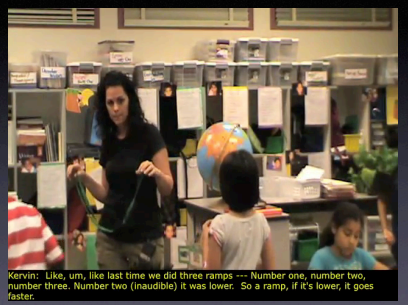
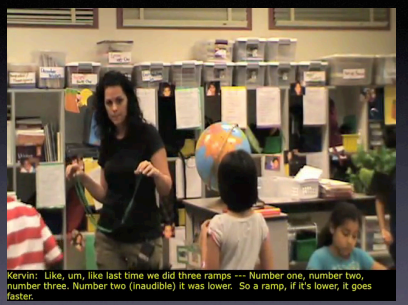
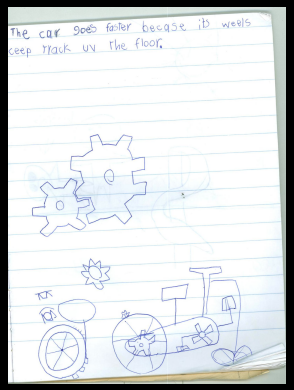
Hammer, Goldberg & Fargason, 2012;
Bresser Fargason, 2013
Radoff & Hammer, 2016





In Isaac's notebook



Sharon: Isaac.

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Physics 11, calculus based intro

Hammer, 2012; Redish & Hammer, 2009

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- Lectures as conversations
  - some planned clicker questions
  - emergent topics around students' thinking

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- Open-ended labs
  - E.g. You can't take the cart off the track or move the track. Figure out a way to mass the cart.
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- Fewer but harder problems for homework
  - Evaluated largely for "sensible effort" (the pursuit)

Hammer, 2012; Redish & Hammer, 2009

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We care about the pursuit

Practices highlighted as Dimension 1 of NGSS

- As essential for objectives of content
- As an objective in itself

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But we keep focusing on "content"

For many reasons

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For many reasons

- The intellectual challenges of recognizing and interpreting students' productive thinking
- Fears of letting students be wrong
- Seeing science as the canon of knowledge
- and students as *lacking* in knowledge and abilities or as having bad knowledge

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- Assessment
  - Aims of objectivity, efficiency, standardization favor assessing for alignment with the canon
  - *But even that is problematic…*

"Content"

26. Brian is twirling a ball on a string over his head. The string represents a pull on the ball. What is another name for the pull on the ball?

A. gravity
B. orbit
C. revolution
D. rotation

From the San Diego Unified Science Benchmark.

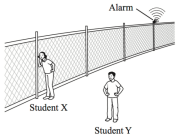
http://messymatters.com/scarequotes/

10 During which of the following steps of the engineering design process would an engineer **most likely** use the Internet?

A. identifying the problem
B. constructing a prototype
C. researching the problem
D. selecting the best solution

And from MCAS tests.

14 A loud alarm attached to a metal fence begins to ring. Student X has her ear against a pole of the fence while student Y stands away from the fence, as shown below. Both students are the same distance from the alarm.



Which of the following statements explains what happens in this situation?

A. Student X hears the alarm first because sound travels faster in solids than in gases.
B. Student X hears the alarm at a higher pitch because solids are denser than gases.
C. Student Y hears the alarm first because sound travels faster in gases than in solids.
D. Student Y hears the alarm at a higher pitch because gases are denser than solids.

We are still fixated on *correctness*, as assessed by authority.

But while correctness (of a sort) is an objective in science, it is a small part of the experience,

and assessment is for *explanatory and predictive power*, not for alignment with authority.

We need…

- Genuine, systemic reform
  - *including with respect to assessment*
  - *but it's a very stable system!*
- Intellectual rigor in teacher education
  - *including with respect to attending and responding to student thinking*

Thanks for listening

If you're interested in more…

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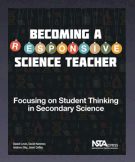

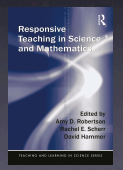

dhammer.phy.tufts.edu