Improving Engineering Students’ Mathematical Sense-making
Ayush Gupta, Andy Elby

Looking for coherence and meaning partly by translating between symbolic relations on the page and relations (causal and functional) in the world
- not just manipulating equations, applying algorithms
- central to students’ success with modeling and design

Mathematical Sense-making

Research Objectives

Determine impact of reformed physics courses on student reasoning in engineering courses
- Curriculum focused on changing students’ approaches to learning
- Follow students from physics course into Basic Circuits Theory and Fluid Mechanics

Diagnose student difficulties with mathematical sense-making
- Weak conceptual understanding?
- Inadequate math skills?
- Epistemological issues?
  - Belief that formal and everyday thinking don’t connect
  - Belief that equations are just problem-solving tools

Sources of Data: Video of students solving problems alone and in small groups

Sources of Data: Exam answers and scores, survey responses, course grades

Example HW Problem
Standing on a cliff, I take one rock and throw it straight up at a speed of 30 m/s. I take another rock and throw it straight down at 30 m/s. Suppose the cliff is 50 meters high.

(a) Just based on common sense, which rock would be moving faster when it hits the ground, 50 meters below? What’s the reasoning for that?
(b) Now find an answer based on the kinematics of constant acceleration: Find $v$ and $a$ for each of the rocks, and find their respective speeds when the hit the ground 50 m below the point of release.
(c) Did your answer to (b) agree with your answer to (a)? If not, try to reconcile the contradiction. Figure out what it is about the reasoning in part (a) or part (b) that doesn’t work. Get it all to make sense!

Case Study: Making sense of hydrostatic pressure equation

Jim** makes a mistake, but sticks to his answer.

His mistake does not stem from faulty physical understanding of pressure...

...or from entrenched difficulties with co-ordinate systems:

With just a little help he could finally resolve his difficulty.

Although Jim is not surprised that math and everyday reasoning “agree”...

...his difficulty stems from a tendency not to try to resolve inconsistency between formal and everyday knowledge

[90x262 to 307x299]

Conclusion

Roadblocks in a student’s mathematical reasoning sometimes stem not from deficient mathematical or conceptual knowledge, but from unproductive views about how math connects to other knowledge.

- Curriculum should explicitly attend to these kinds of beliefs