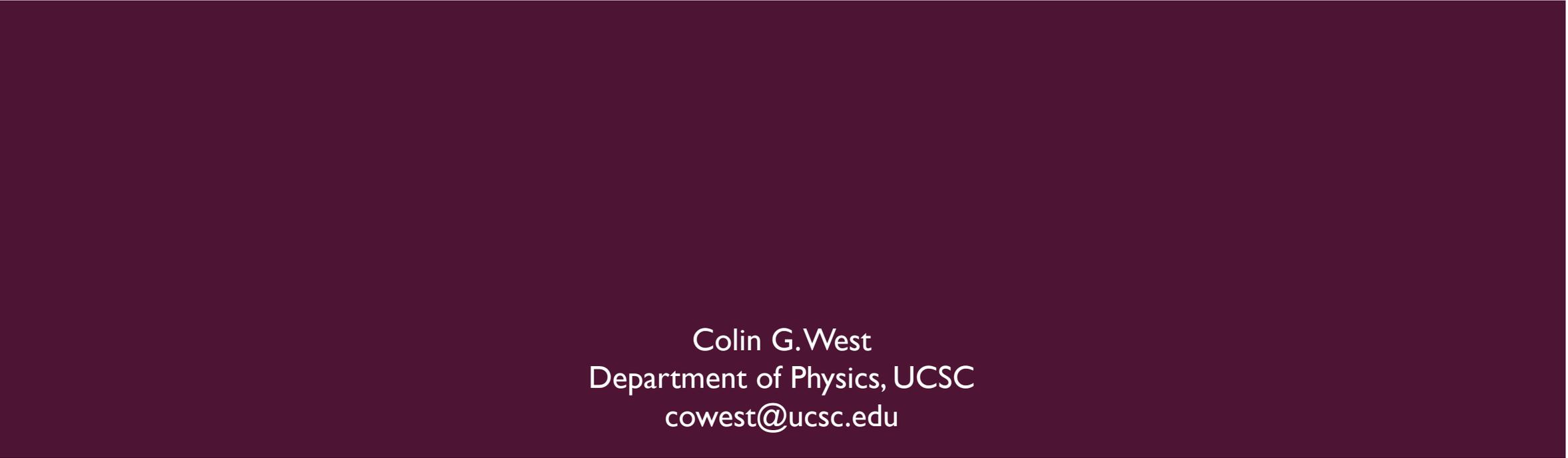




ASSESSING TRADITIONAL ASSESSMENTS IN PHYSICAL SCIENCES

HOW DO WE KNOW WHAT OUR STUDENTS KNOW?



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WHAT IS THE POINT OF A PHYSICS COURSE?

- Taken by many students, not just physics majors
- MCD Bio PLO: “Recognize that biology has a basis in chemistry, physics, and mathematics”
- Earth Science PLO: “Utilize mathematical tools to address quantitative Earth science problems”
- Need students to do more than just “memorize physics facts”

PHYSICS COURSE LEARNING OUTCOMES

- Given a particular physical situation, students should be able to:
 - Identify relevant scientific laws and principles
 - Explain how these laws apply to the situation
 - Describe these laws and principles mathematically
 - Use conceptual and mathematical reasoning to make specific physical predictions

- In other words: “Problem Solving”

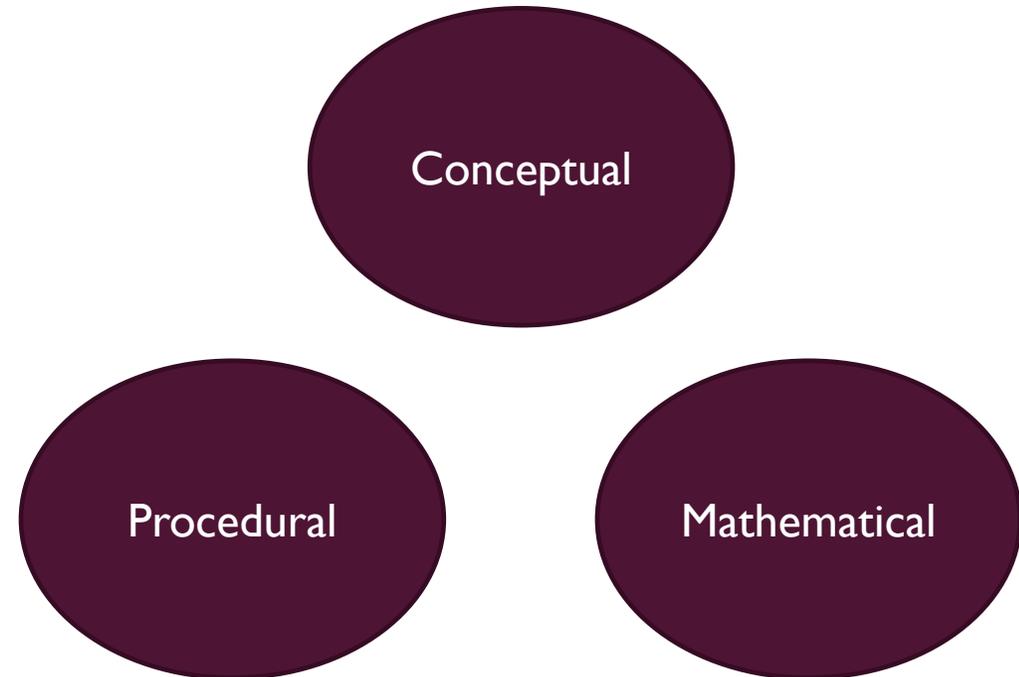
GRADES: A SCIENTIST'S WORST NIGHTMARE

- Does a particular student “understand” physics?
- Can they do “problem solving”?
- Grades full of confounding factors:
 - Did they understand problem?
 - Did they understand concepts?
 - Did they remember the formulas?
 - Were they able to do the math?
- Sciences: traditional reliance on quantitative problems



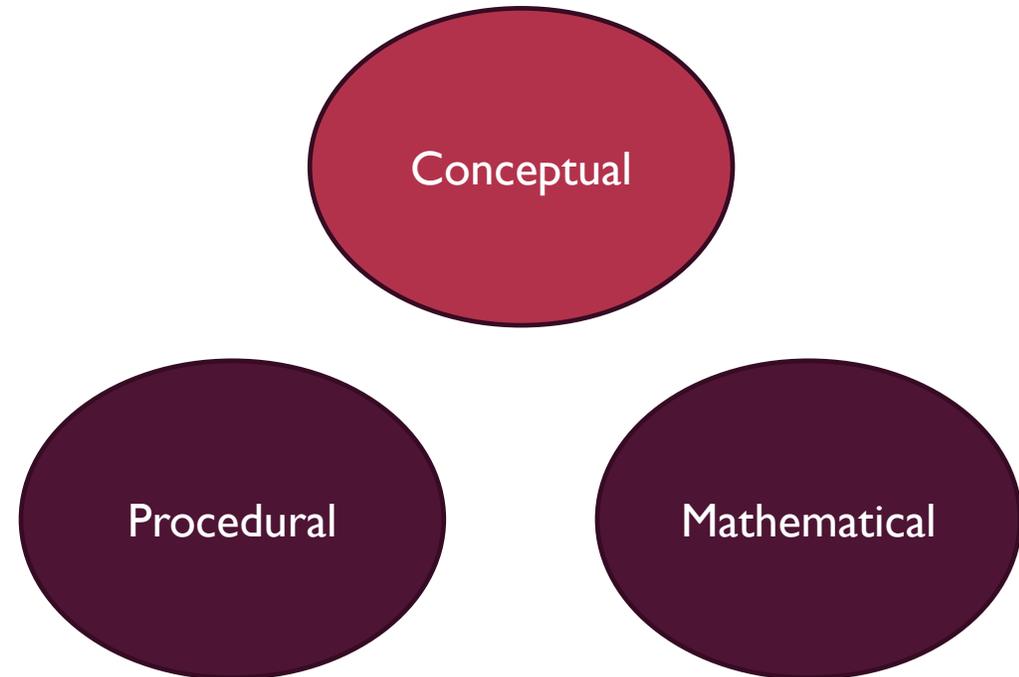
COMPONENTS OF QUANTITATIVE PROBLEM SOLVING

- Conceptual vs Procedural (and “mathematical?”)
 - P. Heller et al., 1992
 - D. Maloney, 1994
- Students may engage these simultaneously!
 - E. Kuo et al., 2013



TARGETED CONCEPTUAL ASSESSMENT

- “Force Concept Inventory”
 - D Hestenes, M Wells, G Swackhamer 1992
 - Huge wake-up call for physics
- Concept Survey of Electricity and Magnetism (CSEM)
 - D. Maloney 2001
- Many others; see R. Lindell, E. Peak, and T. Foster 2007



WHAT WE CAN LEARN

- CSEM Given to large, ~200 student intro physics course
 - Can study patterns based on students background, etc
 - Can compare student outcomes to comparable quiz/exam questions
- Raises some important questions:
 - Student performance on quiz sometimes *better* than on pure concept
 - Significant difference for some topic between “words” and “symbolic” answers?
 - Q4 and Q7: 68% Correct vs 39% correct
 - Identical concept!

WHAT WE CAN'T LEARN

- If students show success on conceptual-only problems, but struggle on complete quantitative problems...
 - Are their difficulties purely procedural?
 - Did they fail to recognize the relevant concepts?
 - Did they override correct concept knowledge with bad procedure?
 - Was the failure in the synthesis of the two?

WHAT COULD WE DO DIFFERENTLY?

- Two major alternatives for targeting these questions:
- Ask students to explain their procedures as part of HW/quizzes
 - Cons: have to give points, resource intensive, skewed by students communication skills, etc.
- Try to assess procedure directly from student's work
 - Cons: Possible instructor bias, skewed by students "working together," etc.

WHAT WE CAN STUDY: PROPOSALS

- At UCSC, can attempt *BOTH* ideas
- 1) Physics 7A/7B: flipped-classroom physics course
 - Small enough to ask students to write out their procedures, score them and give feedback
 - May benefit students (MTH Chi et al, 1996, A. Renkl et al, 1998,)
- 2) Previous years exams from Physics 6C
 - Retroactively attempt to give students conceptual, procedural scores
 - Do these correlate with grade on the problem?
 - Do these correlate with the CSEM conceptual results?

OUTLOOK

- Need more targeted data to determine if we're satisfying our CLOs and PLOs
- Difficult to disentangle conceptual/procedural in sciences
- Targeted “Concept only” assessments help in one direction
- We propose two plans to explore targeted *procedural* assessment tools, assess validity
- Long term: does “flipped classroom” etc. enhance PROCEDURAL skills as well?

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