Faculty Grading of Quantitative Problems: Are Values Consistent with Practice?

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THE PROBLEM

- Grading practices have a tremendous impact on what students do in college courses
- Research in physics education has documented a tension between what instructors say they value in grading quantitative, free-response student problem solutions, and their actual grading practices (Elby, 1999; Henderson, Yerushalmi, Kuo, Heller, & Heller, 2004)
- **Many instructors say they want to see reasoning in a student solution but then grade in a way that either:**
  - **penalizes students for showing reasoning, or**
  - **rewards students for omitting clear reasoning**
- Henderson et al. (2004) propose that this tension exists because hidden internal values conflict with expressed values, and develop the construct of "burden of proof" to explain how faculty resolved these conflicts

THIS STUDY

- Purpose: extend the Henderson et al. (2004) study with faculty in chemistry (n=10) and earth science (n=7), in order to document whether the tension between explicit values and grading practices exists across science faculty more generally

1. What beliefs do science faculty hold about the purpose of grading and about what should be shown in student solutions?
2. How do these faculty resolve the conflict, if any, arising from the stated beliefs when assigning a score to a student solution?
3. Are these faculty more likely to place the burden of proof on themselves, or on the student when assigning a score?

RESULTS

- Same 3 values are present among earth science and chemistry faculty, plus a 4th value (organized, methodical solution with units)
- Including 30 physics faculty from Henderson et al.,2004:
  - 49% of faculty encouraged students to show their work (e.g., graded SSD > SSE)
  - 34% of faculty penalized students for showing work and rewarded omission of work (e.g., graded SSE > SSD).
  - 52% of faculty placed the burden of proof on the themselves when grading.
- Chemistry faculty were more likely than earth science or physics faculty to grade SSD > SSE; the nature of chemical problem-solving may account for this difference (Camacho & Good, 1989)

IMPLICATIONS FOR PRACTICE

- The construct of "burden of proof" can serve as a tool to promote cognitive conflict in faculty
- This cognitive conflict can in turn lead to reflection on and changes in practice

REFERENCES

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Values and conflicts identified by Henderson et al., 2004:

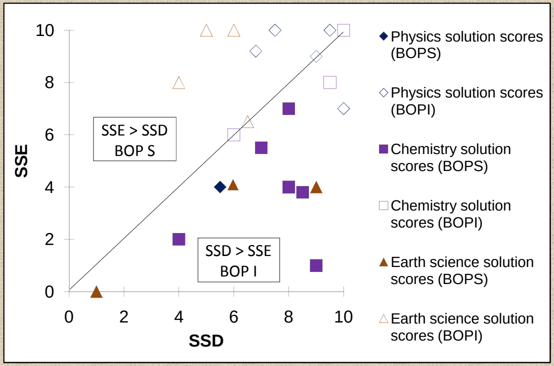
Value 1: desire to see student reasoning

Value 2:
(a) readiness to deduct points from solutions that are incorrect
(b) reluctance to deduct points from solutions that may be correct

Value 3: tendency to project correct thinking onto ambiguous solutions

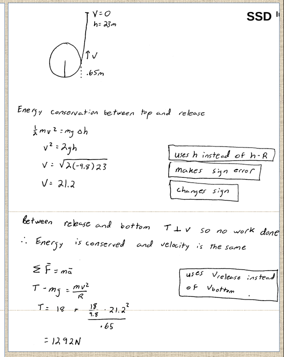
Solution	Solution	Solution	Solution
-Shows reasoning -Correct reasoning -Correct answer	-Little/no reasoning -Incorrect reasoning -Incorrect answer	-Little/no reasoning -Ambiguous reasoning -Correct answer	-Shows reasoning -Incorrect reasoning -Correct answer
NO CONFLICT All values suggest high grade	NO CONFLICT All values suggest low grade	CONFLICT Value 1: low grade Values 2b & 3: high grade	CONFLICT Value 1: high grade Value 2a: low grade

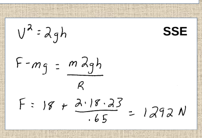
	Instructor's conflict resolution in scoring student solutions	
Conflict resolution	In favor of Value 1	In favor of Values 2 and/or 3
Instructor orientation toward grading	**Burden of Proof on Student** - Explicit evidence of correct knowledge & procedures needed to earn points	**Burden of Proof on Instructor** - Explicit evidence of incorrect knowledge & procedures needed to deduct points
Resulting Grading Practice	A solution will only receive points for the portions of a solution that are correct and are explained by the correct reasoning	For a solution that is not completely correct, as more reasoning is shown there is more opportunity to deduct points
Message Sent to Students	Students cannot get points without showing their reasoning	With the same level of understanding, students may receive more points for not showing reasoning
Effect on Student Behavior	This encourages students to show their reasoning	This discourages students from showing their reasoning



	Chemistry Example	Earth Science Example
Burden of Proof on the Instructor (BOP I)	Instructor C4 : "I don't like [SS]E - although he or she may be smart to get the correct answer and everything right, but from a simple writing you cannot check his thinking, you know. I don't want to take any credit off but I will just tell him directly that he should give people a little more writing to enhance understanding just in case the final result is wrong."	Instructor E3 : "Well, this person got it right and it looks like their logic was right. That's the best paper so far, even though they didn't draw a nice mountain. Guess they just knew it cold and didn't need to put it together like I do."
Burden of Proof on the Student (BOP S)	Instructor C6: "there's no explanation how it [the problem] was done, I cannot see…. if the student knew this or if it was just copied from somewhere. So this student [SSE] might actually be better than this one [SSD] but since the method of solving the problem is not exposed correctly, I cannot grade that work."	Instructor E2: "I don't really know what student E was thinking… I fault student E because nothing is labeled, crudely the work is shown… it's not clear what the work refers to. Personally I'm irritated by this kind of scant answer."

You are whirling a stone tied to the end of a string around in a vertical circle having a radius of 65 cm. You wish to whirl the stone fast enough so that when it is released at the point where the stone is moving directly upward it will rise to a maximum height of 23 meters above the lowest point in the circle. In order to do this, what force will you have to exert on the string when the stone passes through its lowest point one-quarter turn before release? Assume that by the time that you have gotten the stone going and it makes its final turn around the circle, you are holding the end of the string at a fixed position. Assume also that air resistance can be neglected. The stone weighs 18 N.



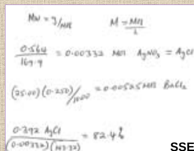


Physics Problem and Student Solutions

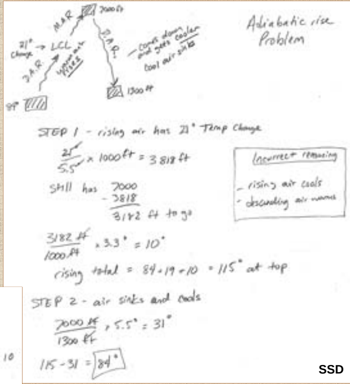
0.564 grams of $AgNO_3$ is dissolved in 25.00 mL of 0.250 molar $BaCl_2$. A precipitate forms and is isolated and weighed. Its mass is 0.392 grams. What is the percent yield of the reaction?

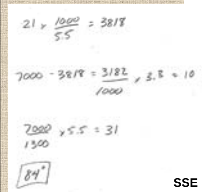
Chemistry Problem and Student Solutions

Solutions D and E elicit conflict between values:
- SSD shows thinking, has explicit errors, has correct answer
- SSE does not clearly show thinking, but has correct answer



An air parcel is forced to rise over a mountain to a height of 7000 feet. The air parcel's starting temperature is 84°F at sea level on the windward side of the mountain. It reaches its dew point at approximately 63°F. What is the approximate temperature of this air parcel when it descends back to 1300 feet on the leeward side of the mountain? Assume that the air parcel is not saturated during its descent.





Earth Science Problem and Student Solutions