SCHOOL OF CHEMICAL BIOLOGICAL AND ENVIRONMENTAL ENGINEERING

Better Questions for Peer Instruction

Ying Cao and Milo D. Koretsky

Contact:
caoyin@oregonstate.edu

I. Our motivation: help instructors write better questions.

Peer instruction (PI) is an evidence-based strategy for developing students' conceptual understanding. In PI, students answer a short concept-question (pre), then discuss it with their peers, and finally answer the same question again (post) [1]. We look as delivery of PI where students must also write explanations justifying their choice.

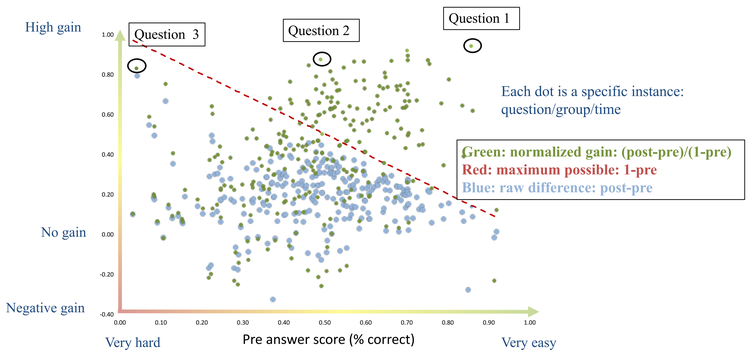
Question attributes can affect the degree that students will progress through the discussion. In this correlative study, we investigate how question-specific attributes relate to pre-post gains in correct answer choices.

II. We ask: (1) what questions are good, and (2) what's good in them?

We consider question difficulty, content addressed by the question, and types of understanding needed to answer the question.

We look for **good questions** in which students gain more correct answers and better conceptual understandings.

Potential better questions: higher gains



Question ID	Correct Pre	Correct Post	Difference	normalized gain
Question 1	0.70 (easy)	0.97	0.27	0.91
Question 2	0.49 (medium)	0.93	0.44	0.87
Question 3	0.04 (hard)	0.83	0.79	0.83

III. Plot student gains and see patterns.

We draw data from multiple groups of engineering students taking sophomore courses covering conservation principles. Through a web-based interactive platform [2], questions, student answer choices, and written justifications were collected.

Preliminary analysis shows that questions of mid-level difficulty were asked most often by instructors and also have the highest absolute gain. Easier questions show the higher normalized gain.

IV. Case study on three potential better questions.

Ongoing analysis includes classification of question content and written responses of students to relate those to gains [3].

Emergent coding process of written justifications has been conducted on the three questions listed below.

Question 1

Ammonia is compressed isothermally at 300 K until liquid NH_3 forms at pressure P_a. In a second container, ammonia is compressed at 350 K until it condenses at a pressure P_b. The pressure P_a is _____ P_b.

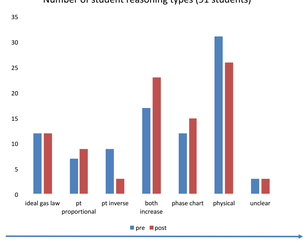
- greater than
- less than
- equal to

Please explain your answer in the box below.

Please rate how confident you are with your answer.

substantially unsure | moderately unsure | neutral | moderately confident | substantially confident

Number of student reasoning types (91 students)



More productive reasoning

Question 2

Consider the reaction 2A + B --> 2C in a flow reactor at steady state. The feed stream consists of 100 mol/s of A, 200 mol/s of B, and 50 mol/s of C. What is the flow rate of C exiting the reactor if A is consumed at a rate of 5 mol/s?

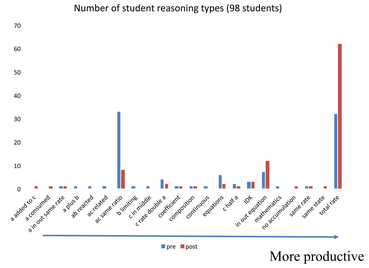
- 5 mol/s
- 10 mol/s
- 55 mol/s
- 60 mol/s
- 150 mol/s

Please explain your answer in the box below.

Please rate how confident you are with your answer.

substantially unsure | moderately unsure | neutral | moderately confident | substantially confident

Number of student reasoning types (98 students)



More productive reasoning

Question 3

How many **independent** material balance equations can be written for the splitting point shown?

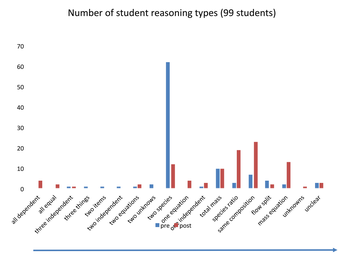
- 1
- 2
- 3

Please explain your answer in the box below.

Please rate how confident you are with your answer.

substantially unsure | moderately unsure | neutral | moderately confident | substantially confident

Number of student reasoning types (99 students)



More productive reasoning

V. Question 1. Hard to say.

Wrong /hollow/right reasons can all get the right answer.

Some wrong and hollow reasoning increased.

Some correct and convenient reasoning increased.

Some in-depth but inconvenient thinking decreased.

VI. Question 2. Significant absolute gain!

Clarification of the mathematics.

Better conceptual understanding of the situation.

VII. Question 3. Huge absolute gain. Exciting!

A similar question was discussed through Peer Instruction in the same class right before question 3.

Student spent longer time in discussing question 3 (15 minutes, compared to typically 7 minutes).

VIII. Next steps: look at the same questions in different groups.

Some questions always had high gains across different groups (such as question 1 and question 2).

Some questions had a big range of gains when applied in different groups (such as question 3).

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