Computer Based Assessments, Peer Tutors, and Elicitation Questions in the UGA General Chemistry Program

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Outline

- Introduction
- Interview logistics
- Interview results
- Elicitation questions
- Conclusions

Introduction

- Previous PRISM meetings I have discussed our IRT analysis and results.
- Today's discussion is on Carrie Shepler's research in developing chemistry elicitaion questions.
- Item Response Theory (IRT) research
  - Provides invaluable data regarding student ability levels
  - Insufficient to determine ***how*** students arrive at answers
- Interviews in which students delineate problem solving approaches are vital to our understanding of their thought processes.

Interview Logistics

- Students randomly selected following each exam in Freshman Chemistry I and II.
  - Specific questions selected pre-interview
  - Approximately 85 interviews to date
  - Two interviewers (Carrie and Kim)
  - Invitation issued via email
  - Students were not interviewed by their own instructor
  - Internal Review Board protocol followed

Interview Results

- There is a very strong correlation between the score earned and the description of problem solving approaches.
    - Higher level students demonstrate less dependence on rote memorization.
    - Higher level students show greater ownership of concepts.

Interview Results

- Ownership of information is important
- A/B level students
  - "***I*** knew that…so ***I*** took this number…"
- C-F level students
  - "Dr. Atwood said…and I remember that in class he did this…"
  - "There was one just like this on the practice test."
  - Lower level students often "remember" information incorrectly.

Interview Results

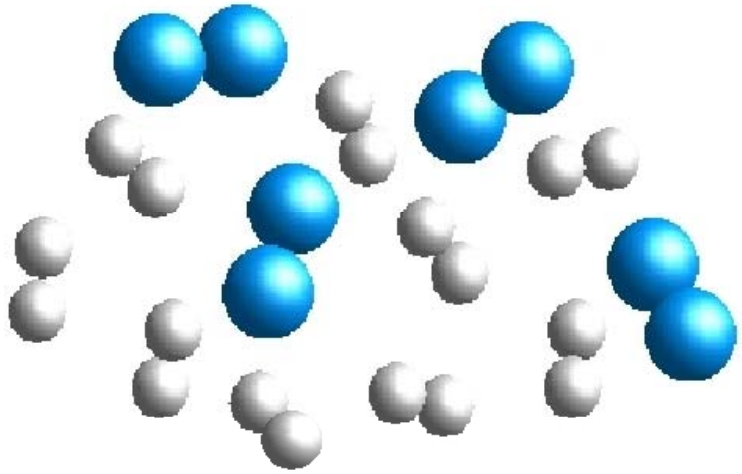
- Vocabulary use for lower level students is critical
- Student use of terms that they cannot define
    - Correlating reliance on key terms as clues for problem-solving.
- Use of multiple words to describe one concept
- Instructors' use of vocabulary
    - Previously examined in regard to non-technical words in biology multiple choice questions[1]

1. Ingram, E.L., Nelson, C.E. *The American Biology Teacher*, Vol. 68, No. 5, May 2006

Interview Results

- Reliance on key terms
  - "Depicted below is a reaction vessel containing a mixture of N_2 and H_2 gas (before reaction begins). The blue spheres represent nitrogen atoms and the white spheres represent hydrogen atoms. Nitrogen and hydrogen react to form ammonia, NH_3.

$$N_2\,(g) + 3\,H_2\,(g) \rightarrow 2\,NH_3\,(g)$$



Interview Results

- A/B level students could answer this question correctly.
- Many students who could not answer the question on the exam could reason their way through it when told that it was a limiting reagent problem.

Interview Results

- Multiple words to describe one concept
  - Molarity, *M*, molar concentration
  - Molar mass, molecular weight, atomic weight, formula weight
  - Enthalpy, enthalpy of reaction, ΔH_{rxn}, ΔH, heat of reaction, heat of neutralization

Interview Results

- Instructor use of vocabulary
  - Instructor vocabulary is vast in comparison to student vocabulary.
  - Instructors often interchangeably use words with technically different definitions.
    - Note the use of the word “atom” to describe H_2 in the previous exam question.

Interview Results

- Previous IRT research showed that only higher level students can determine the number of ions in a formula unit.
  - Basic lack of understanding of the difference between atoms, ions, and molecules?

Interview Results

- Confusion of atoms and ions
  - Most students can correctly identify the products of the reaction between HBr and $Ba(OH)_2$.
  - When asked to identify the image depicting the products of the reaction, lower level students selected the image containing Br_2 as opposed to two Br^- ions.

Interview Results

- Mole ratios
  - Most students understand and can apply mole ratios from balanced chemical equations.
  - Only higher level students grasp the concept of mole ratios from chemical formulas.

Interview Results

- Example problem
  - "What is the molar concentration of the OH^- ions in a 0.01 *M* solution of $Sr(OH)_2$?"
  - Common incorrect answers
    - 0.01 *M*
    - Calculation of the number of Sr^{2+} ions
    - 0.01 *M* / 3 ions = 0.0033 *M*
    - (0.0033 *M*)(2 ions) = 0.0066 *M*

Interview Results

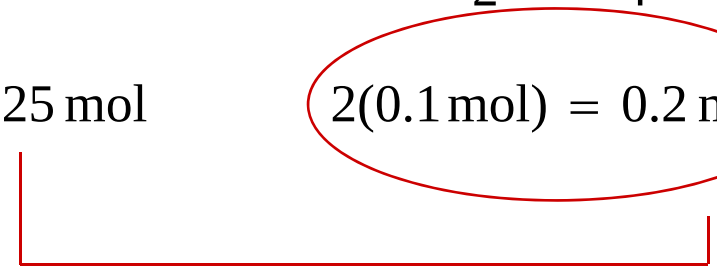
- Limiting and Excess Reagents
  - Most students can:
    - predict the formula of a salt formed in a neutralization reaction.
    - determine the concentration of the salt given the volumes and initial concentrations of reactants.
  - Only A/B level students can calculate the concentration of the excess reagent.

Interview Results

- Many A/B level students answer the excess reagent problem correctly, but their reasoning is flawed.

$$2LiOH_{(aq)} + H_2SO_{4\,(aq)} \rightarrow Li_2SO_{4\,(aq)} + 2H_2O_{(aq)}$$

$0.25\,\text{mol}$ $\quad 2(0.1\,\text{mol}) = 0.2\,\text{mol}$ $\quad 0.1\,\text{mol vs. } 0.125\,\text{mol}$



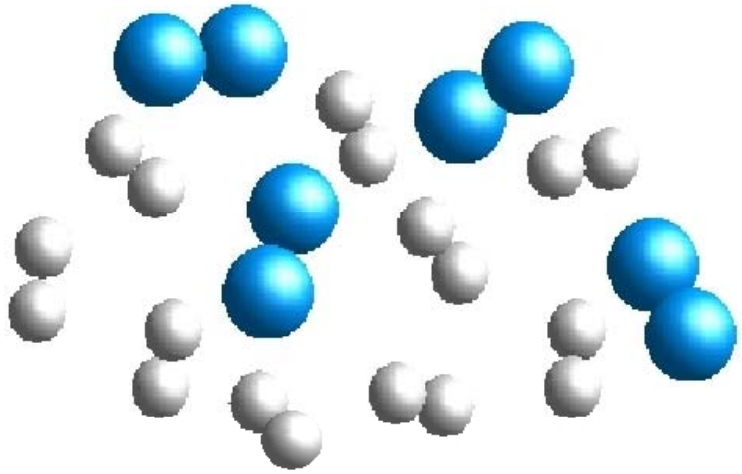
Elicitation Questions

- Designed to evaluate student ability level on a specific topic:
  - Easily administered
  - Graded objectively
  - High quality distracters derived with student input
  - Incorrect answers must provide some input regarding ability
  - Multi-tiered

Example Elicitation Question

- Reliance on key terms
  - Part 1) “Depicted below is a reaction vessel containing a mixture of N_2 and H_2 gas (before reaction begins). The blue spheres represent nitrogen atoms and the white spheres represent hydrogen atoms. Nitrogen and hydrogen react to form ammonia, NH_3.

$$N_2\,(g) + 3\,H_2\,(g) \rightarrow 2\,NH_3\,(g)$$



Example Elicitation Question

2) Select *all* of the statements below that help explain your answer to part 1).

-Only three N_2 will be used because all of the H_2 will be used first.

-Only NH_3 should be present because it is the only product.

-Fourteen NH_3 should be shown because you can produce eight NH_3 from four N_2 and six NH_3 from nine H_2.

-No H_2 should be shown because all of it will be used.

-Only six NH_3 will form because that is all the initial amount of H_2 will allow to form.

-Eight NH_3 should be shown because that is how many can form based on the initial amount of N_2.

-One reactant is completely used up. There will be some of the other reactant in the reaction vessel after the reaction is complete.

-There should be two N_2 left over because eight NH_3 minus six NH_3 (the amounts possible based on the initial amounts of reactants) equals two NH_3 molecules.

-The amount of product formed is determined by the initial ratio of reactants.

Conclusions

- Student interviews provide extremely valuable information pertaining to student thought processes
  - Improved classroom performance by instructors
  - Development of elicitation questions that could be used by numerous colleges and universities

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