Learning Assessment of Core Outcomes
Focus 2009-2010: Critical Thinking and Problem Solving

Critical Thinking Rubric Applied to CH243 Posters

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When your project is completed, please describe the method(s) you used:

Two different chemistry instructors used the WSU Math Rubric (modified for chemistry) to analyze the Critical Thinking Outcome for five CH243 Organic Chemistry Research Posters. The assignment for the students was to present a poster of the results of their 3- week independent research project that involved either a two-step synthesis or an extraction of an organic compound. Students were required to prove if their synthesis or extraction was successful by calculating the percent yield of product and using at least one of several analysis techniques available in the lab (melting point, gas chromatography, Fourier Transform Infrared Spectroscopy, or Nuclear Magnetic Resonance Spectroscopy).

The results of our analysis for these 5 posters are summarized below:

	CH243 PosterResults					
Poster Number	**#1**	**#2**	**#3**	**#4**	**#5**	**Average**
Grading Rubric Analysis						
1. Identifies the Specific Situation, Problem, or Question	5	3	6	5	6	**5**
2. Identifies (and notes) the Chemical Properties Applicable to the Specific Situation, Problem, or Question	4	6	6	6	4	**5.2**
3. Demonstrates How the Chemical Properties Apply To This Specific Situation, Problem, or Question	6	6	6	6	5	**5.8**
4. Identifies (and notes) the Chemical Definitions and Notations Applicable to the Specific Situation, Problem, or Question	6	6	6	6	5	**5.8**
5. Demonstrates How These Definitions And Notations Apply to the Specific Situation, Problem, or Question	6	6	6	6	4	**5.6**
6. Synthesizes the Information Above Into A Chemically Consistent Solution to the Specific Situation, Problem, or Question.	3.5	6	6	5	5	**5.1**
					Overall Average	**5.4**

NOTE: 1 corresponds to improvement needed and a 6 corresponds to Mastery of the skill.

What did you learn?

We anticipated that the last term of organic chemistry students would demonstrate a high level of critical thinking skills. Applying the Critical Thinking grading rubric to these posters revealed that these students are very good at critical thinking skills with an overall average of 5.4 out of 6, where a score of 6 indicates Mastery of the specific skill. Students will need more instruction throughout the course about how to identify the organic chemistry problem or question for their project. Moreover, some students were not clear about which chemical properties need to be applied to their problem. Finally, many students were not sure how to synthesize the information into a chemically consistent solution.
However, applying this one rubric to one assignment does not indicate if these students learned these critical thinking skills from taking CH243 at PCC, or if these skills were learned in other courses. In order to address this concern, the same critical thinking rubric needs to be applied to the posters presented by the CH241 students. Another bias for this data is that most of the organic chemistry students are extremely motivated to enter graduate programs, professional programs (Medical School, Pharmacy School, etc.), so these groups of students are very high achievers, as reflected in the high quality of all the posters presented this year.

What is your plan?

In order to assess if the students are learning critical thinking skills as a result of taking organic chemistry, a baseline analysis of student work will be needed. Since a poster presentation for a literature research project is assigned in CH241, the same rubric should be applied to these posters. Then a direct comparison can be made for the first term posters compared to the third term posters to accurately measure if the students are improving in the application of their critical thinking skills for a research project.

Additional improvements to students' critical thinking skills can be implemented in future research projects in this course, through the instructor providing additional guidance about how to identify the organic chemistry problem or question for their project. Giving feedback to students on weekly written lab reports also help to improve these critical thinking skills.
PCC Cascade

Critical Thinking Rubric Applied to CH106 Labs

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When your project is completed, please describe the method(s) you used:

We used the WSU Math Rubric to analyze the Critical Thinking Outcome for Chemistry Labs.

We reviewed the same question from 6 student labs from chem 106. The question was:

Review your lab notes to list any possible experimental errors you observed while performing this lab, and explain how they might lead to an increase or decrease in your result.

What did you learn?

We learned that although we "feel" that we are teaching critical thinking in all of our lab experiments, our student may not be mastering the outcome. We learned that some students may have understood the concept, that they may not be able to apply the skill effectively. We learned that some students do learn to identify the problem and are able to demonstrate their skill effectively. We learned that this was actually a useful exercise to use the CT Rubric to assess our student development in this area. We are professional chemists and not trained teachers. We can use the Rubric to build assignments to both better teach critical thinking skill and to better assess student development in this area.

Our courses are heavily concept based courses, and in light of teaching so many difficult concepts we can easily lose sight of focusing on teaching and on correctly evaluating student development for this core outcome.

What is your plan?

Our plan is to review and rewrite all of our lab questions relating to critical thinking starting with the first term in chem 104. We feel that the question we asked is good, but that we need to better guide students through the process in smaller steps in each lab through consistent incrementally increasing the degree of difficulty. We will provide redundancy from lab to lab with similar questions so that students are not only better able to identify the problem using critical thinking, but that they are also developing a mastery level in applying this critical thinking skills.

1) Explain potential experimental errors when reviewing data and observations:
   Rubrick:
   1) Identifies the specific situation, problem or question:
      2, 4, 6, 6, 4

   2) Identifies the chemical properties applicable to the specific situation, problem or question:
      3, 4, 5, 6, 2

   3) Demonstrates how the chemical properties apply to the specific situation, problem or question:
      2, 3, 6, 4,1

   4) Identifies the chemical definitions and notations applicable to the specific situation, problem or question:
      1, 4, 6, 6, 1
   5) Demonstrates how these chemical definitions and notations applicable to the specific situation, problem or question:
      1, 3, 5, 4, 1
   6) Synthesizes the information above into a chemically consistent solution to the specific situation, problem or question:
      1, 4, 6, 5, 2

Critical Thinking in Chemistry Concept Tests

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When your project is completed, please describe the method(s) you used:

Personal response system (clickers) used in conjunction with conceptual questions provide students an opportunity to test their critical thinking skills and provide instructors a method for assessing students' critical thinking skills in the classroom. During lecture, concept tests are shown overhead, and then students anonymously answer the question via clickers. It is common to ask 2 – 10 concept tests per lecture. This is done in several different chemistry courses.

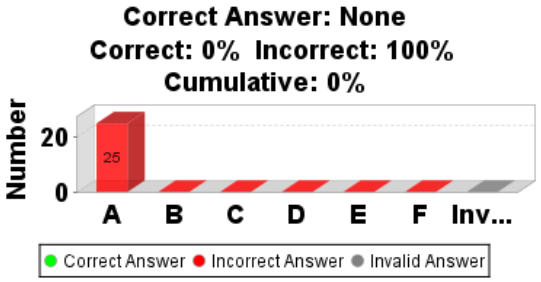
Example 1

Students are first reminded of previous foundational concepts, than asked to respond individually with clicker to the following concept test:

*Which of the following polar molecules would have the **strongest** intermolecular forces of attraction? (Remember, IMFs mean forces of attraction between molecules of the same type in a pure sample)*

A. HF
B. HCl
C. HBr
D. HI

Results shown as a bar graph to the right indicate that students successfully applied the concepts of polarity and Coulomb's law to unanimously determine the correct answer.

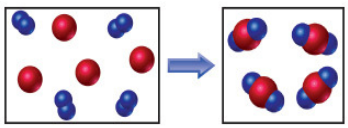


Example 2

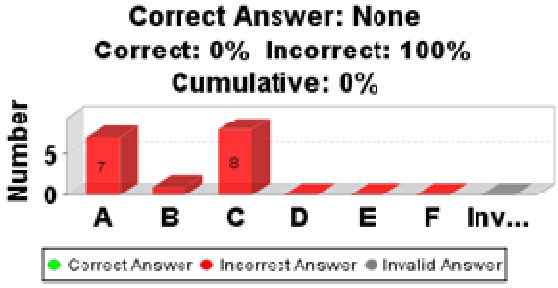
Students were asked to review balancing chemical equations outside class. They were presented with the following question, which asks them to balance a chemical equation based on a particle level diagram and general symbols instead of real elements. They have not seen this combination in this course before.

The reaction between reactant A (blue spheres) and reactant B (red spheres) is shown in the following diagram. Which chemical equation best describes the reaction?

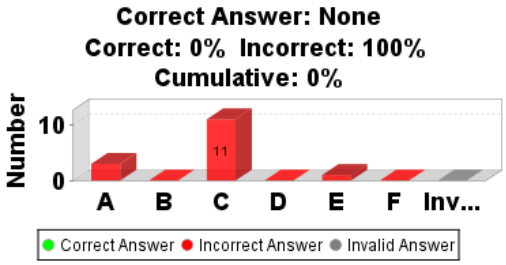
A. $4A_2 + 4B \rightarrow 4A_2B$
B. $A + B_2 \rightarrow AB_2$
C. $A_2 + B \rightarrow A_2B$
D. $2A + B_4 \rightarrow 2AB_2$
E. $A_2 + 4B \rightarrow 2AB_2$



Results show that there were some misconceptions, and though students correctly interpreted the number of particles, half of them did not make the step to showing the lowest whole number ratio.



Students were then asked to talk to their group and convince each other of their answer. Then they re-voted, and results show that most of them corrected their critical thinking errors – 80% answered correctly.

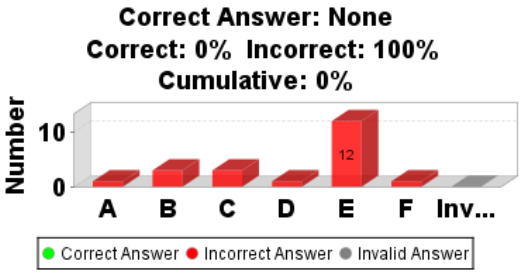


Example 3

Students were told that breaking bonds or overcoming any force of attraction takes energy (endothermic) and forming bonds releases energy (exothermic). They were then asked to interpret that concept using the following concept test.

Which of the following reactions is most likely to be exothermic?

(a) Mg (s) → Mg (g)
(b) Mg (g) → Mg^{2+} (g) + 2 e^-
(c) $MgCl_2$ (s) → Mg^{2+} (g) + 2 Cl^- (g)
(d) H_2 (g) → 2 H (g)
(e) 2 F (g) → F_2 (g)
(f) all these reactions give off energy



Results show that 70% were successful in their critical thinking of that problem.

What did you learn?

While this is just a sampling of responses, we can see that concept tests can be an effective way to assess students' critical thinking skills during class. This type of in-class assessment gives the instructor the opportunity to directly intervene on critical thinking errors when appropriate.

What is your plan?

- For meaningful results, instructors must consider the students' assumed background knowledge, wording of the conceptual questions, and choice of common incorrect answers.
- To get a more accurate picture of critical thinking processes, students may be asked to explain their reasoning.