Exploring Students’ Understanding of Introductory Acid-Base Chemistry

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Background

What is Lesson Study?
• A collaborative classroom inquiry approach useful for planning, observing, and revising a lesson to improve student learning.
• A team of instructors work together to observe and collect evidence during a lesson to assess how students think, behave, and learn lesson objectives.
• Analysis of observations leads to revising the lesson to better meet student learning outcomes.

Acid/Base Chemistry in CHM 104
• Identified by students as the most challenging unit in the course
• Introduced in laboratory Experiment #5: Properties of Acids and Bases

Experiment #5 Learning Objectives
Use pH measurements to:
A. Determine the relationship between the strength of an acid and the strength of its conjugate base.
B. Calculate the concentrations of a weak acid solution and a strong acid solution.
C. Determine the relationship between acid strength, concentration and percent ionization.

To achieve these objectives, students learn the following skills:
1. Write balanced equations for acid/base reactions with water.
2. Calculate acid concentration for pH measurements.
3. Calculate $K_a$ or $K_b$ values.
4. Correctly calibrate and use a pH meter.

Exp 5: Properties of Acids & Bases

Before:

Pre-lab Preparation:
• Students only required to read lab procedure.
• Information in lab manual described behavior of weak acids and bases, but omitted strong acids and bases. Students arrived to lab with minimal understanding of the differences between the two.

In-lab Activities:
• Students listened to a 30 – 40 min in-lab lesson during which student attentiveness and participation was observed to be lacking.
• Students measured pH of 6 solutions twice, which was time consuming and unproductive use of time.
• Solutions included a strong acid, weak acid, two weak bases, a neutral salt, but no strong base.
• Students expressed a great deal of confusion and frustration.

After:

Pre-lab Preparation:
• Background information in lab manual was expanded to include descriptions of both strong and weak acids and bases.
• Students watch an instructional online video.
• Students complete a pre-lab assignment.

In-lab Activities:
• In-lab instruction time is used to review students’ pre-lab assignments.
• Students write pre-lab quiz to assess knowledge base.
• Students measure pH for only 7 solutions, including a strong base.
• Lab is completed more quickly, allowing more time for questions and review of concepts.
• Objective C was removed; percent ionization calculation was added to Objective A.
• Students given a post-lab quiz which was compared to the pre-lab quiz.
• Students appeared less confused and asked more insightful questions.

Results & Conclusions

Predict acid/ base strength from $K_a$ or $K_b$ (Bar 1): 56% of students correctly performed skill before lab session; 39% of students showed improvement after lab.

Write Balanced Equations (Bar 2): 72% of students performed skill correctly before lab; 28% of students declined in ability after lab. Most post-lab errors were due to missing charges, which likely reflected carelessness after a long lab period rather than a decrease in understanding.

Estimate pH of Conjugate Acid or Base (Bar 3): 17% of students correctly performed skill before lab. Results after lab were mixed: 22% improved, 28% declined, and 33% showed no change. It appears that adjustments to the lesson are still required to address this concept.

Calculate Concentration from pH (Bar 4): Ability to perform this skill increased from 19% before lab to 70% after lab.

Calculate Percent Ionization (Bar 5): Just under 50% of students performed skill correctly before lab; 30% showed improvement after lab.

The revised experimental procedure has been adopted by the Chemistry and Biochemistry department for use in CHM 104 labs in Spring 2014.