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ADI Laboratory Model

Stage 1: Identifying Research Question

Stage 2: Develop Method, Carry out Investigation

Stage 3: Develop Initial Group Argument

Stage 4: Argumentation & Feedback Session

Stage 5: Writing a Report

Adapted from: Walker & Sampson. (2013). *JRST*, 50(5), 561-596.

Experimental Design

1. Selection of Research Question – beginning of class:

- How well does a weak (acid or base) buffer counteract pH shifts from strong acid and base?
- What is the pH effect of the (acid or base) to conjugate (acid or base) ratio used in preparing a weak acid buffer?
- How does pKa relate to the pH of a weak acid buffer?

2. Materials, procedure, and data collection planning – 20 min:

- 4 buffer system options (using solid reagent and solution)
- Solution preparation parameters
- Suggested techniques for measurements
- Group-developed experimental design, procedures, data tables, solution preparation calculations

3. Carrying out investigations – 60 min.

4. Group data analysis, argumentation, presentation preparation – 40 min:

- Use of tabletop whiteboards for figure/model generation and argument drafting.
- Directly presented from whiteboard or other format.

5. Class presentations – 45 min.

6. Report writing – after class:

- Open-guidelines for methods and data/results sections.
- Claim-Evidence-Reasoning structure for conclusions.
- Guiding conceptual questions to prompt in-depth explanations as reasoning.

Results

Perceptions

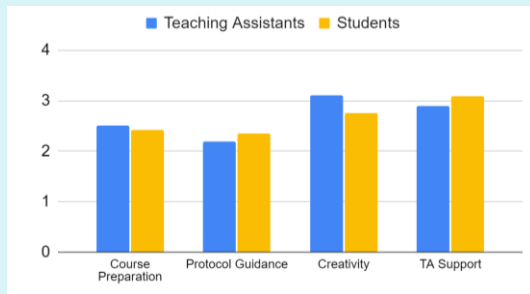


Figure 1. Comparison of the degree of positive perceptions between students and teaching assistants.

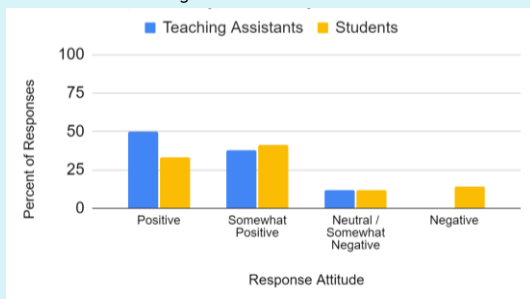


Figure 2. Comparison of attitudes in descriptions about degree of group collaboration, creativity, and autonomy between students and teaching assistants.

It was a very positive experience. I really enjoyed getting to work with my group to come up with our protocol. In addition, the TA did his best to reduce the stress we experienced during this lab and always helped when we had questions. I would say that I have recently become less stressed for chemistry lab.

The whole group worked together although I found myself confused. Nonetheless, it was a good challenge and made me connect concept to calculations.

We displayed the same level of collaboration as the previous weeks. Most of my group did not understand the lab enough to find it fun or to be creative with designing the protocol.

Outcomes

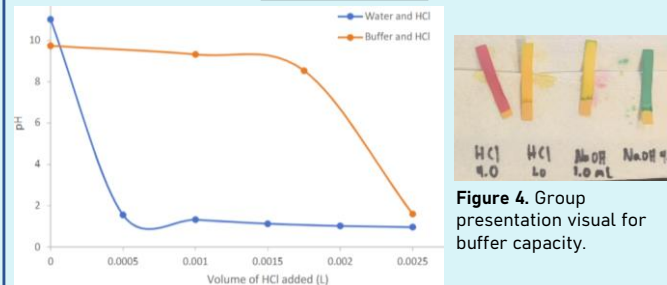


Figure 3. Buffer capacity experimental results with a control.



Figure 4. Group presentation visual for buffer capacity.

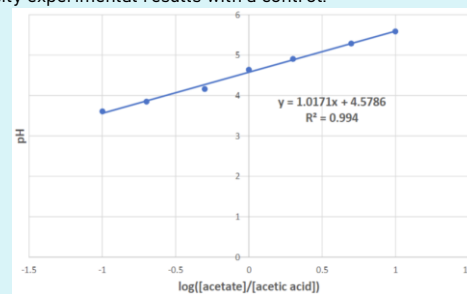


Figure 5. Conjugate ratio experimental results plotted to demonstrate the Henderson-Hasselbalch equation.

- All groups had unique experimental design with a range of sophistication and detail.
- Decisions for communicating findings varied greatly.
- Scores students received were higher than average.

Descriptives

	Group	N	Mean	SD
Notebook	average	398	8.738	1.395
	buffers	370	9.393	1.986
Post-lab	average	398	11.750	3.448
	buffers	377	13.070	4.231

Table 1. Descriptive statistics and dependent t-test for assignment scores relative to the average.

Paired Samples T-Test

	Measure 1	Measure 2	t	df	p
Average Notebook	-	Notebook Buffers	-5.851	369	< .001
Average Post-lab	-	Post-lab Buffers	-7.380	376	< .001

Note. Student's t-test.

Revisions Feedback

Students:

- More guidance/structure
- Logistics should be clearer
- Accountability to participation in group
- Allow for preparation in advance
- Greater difference between research questions
- Expand information on each research question

Teaching Assistants:

- More guidance for getting started
- Add conceptual background
- Calculation scaffolding
- Less freedom and more structure

Conclusions and Future Directions

Conclusions:

- **Collaboration** increased because groups had to work together to plan and carry out an experiment
- **Creativity** increased because the prescribed procedure was removed and replaced with loose parameters
- Groups were overall **successful** at a more **authentic** lab task, but would prefer increased structure
- ADI model can be effectively modified to function in single-week experiments

Future Directions:

- **Scaffold** year-long lab sequence toward ADI
- Refine **research questions** to make experimental goals more distinct
- Increase **parameters** and provide more extensive **suggestions** for procedure development and data analysis
- Embed in 3-week **project**: “Acid-Base Conjugates”