Evaluation of Students’ Realization of Laboratory Learning Goals Associated with an Acid/Base Buffer Experiment in a Large, Introductory Undergraduate Lab


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Introduction

- This study assesses students’ achievement of learning gains & laboratory learning goals (LGs) related to an acid/base buffer experiment in a large (>1,600 students) introductory chemistry course (CHEM 123 at UBC).
- Concern from the Chemistry faculty over UBC Chemistry students’ lab skills development prompted this initiative. The Chemistry Department initiated research, with support from the Carl Wieman Science Education Initiative (CWSEI), to review the chemistry lab program by gauging students’ learning gains.
- Multiple-choice/true-false questions were developed to measure students’ achievement of laboratory LGs through learning gains before and after their experiment was complete.1

Research Design

Assessment LG achievement

- An iterative cycle of assessment was used to develop and refine questions to ensure students appropriately understood the meaning of the questions, while making sure that the question still reflected the intended LGs.2
- Written Assessment Instruments (i.e. Quizzes)
- Student (Think-Aloud) Validation Interviews
- In-Lab Observations

Quiz Administration and Processing

- PRE-quiz: students randomly received either Quiz Version 1 or Quiz Version 2.
- POST-quiz: ~1/2 of the students received the same quiz version as in PRE testing, while the others received the opposite quiz version.
- This is to examine whether students will score differently on the POST quiz when they had a different starting point (i.e. different PRE quizzes): the presence of a pre-test effect will be assessed.

Results: Version 1 Quiz Scores

<table>
<thead>
<tr>
<th>Name</th>
<th>HPO−(aq)</th>
<th>H3PO4(aq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norm</td>
<td>0.3 x 10^−3</td>
<td>0.3 x 10^−3</td>
</tr>
</tbody>
</table>

Which of the following is a weak acid?

- H3PO4(aq)
- HPO−(aq)
- PO43−(aq)
- H2PO−4(aq)

Question 4, Quiz Vers. 1:

- Answer = True, HPO−(aq) is a weak acid.
- Group 3 experienced a learning gain while Group 2 did not, resulting in an overall learning “loss.”
- Validation interviews provided no explanations towards possible reasons for learning loss.

Results: Version 2 Quiz Scores

<table>
<thead>
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</table>

Which of the following is a weak acid?

- H3PO4(aq)
- HPO−(aq)
- PO43−(aq)
- H2PO−4(aq)

Question 3, Quiz Vers. 2:

- Answer = D; majority of students’ answers answered “A”.
- When preparing your buffer solutions, what type of glassware will you use?
  a. Volumetric glassware, because you need to know your volumes exactly in order to measure pH.
  b. Volumetric glassware, because you need to know your volumes exactly in order to calculate the volume of each drop.
  c. Non-volumetric glassware, because you need to know the pH measurements are only approximate.
  d. Non-volumetric glassware, because the volumes are only approximate.

- While volumetric glassware is not necessary to prepare buffer solutions, students use volumetric glassware to dilute the buffer.
- This could be linked to students choosing option “A,” and could suggest that students are not critically thinking about the experimental procedure.
- In student validation interviews, 5 out of 7 choose “A.”
- Three interviewees had already prepared for this lab but only one recognized that non-volumetric glassware is appropriate.

Future Work

- Further analysis of the students’ responses will involve cross-referencing the individual answers of each student on both their pre- and post-experiment quizzes.
- Comparison of comments from Expert validation interviews (quizzes done by faculty) versus Student validation interviews to see if the interpretation of questions is the same compared to the researchers and to the students.

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References