Introduction

Attainment of Learning Goals Associated with an Electrochemistry Experiment in a Large, Introductory Chemistry Laboratory Course


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Testing student achievement of Learning Goals (LGs) in a reliable manner is essential to measure student learning and assess the effectiveness of curriculum reforms. Instruments, in the form of pre- and post- quizzes, were developed to assess student achievement of LG’s in Experiment #11: Electrochemistry: Galvanic Cells and the Nernst Equation. Quizzes were validated with students and the Research Team, and underwent an extensive refining process before being employed pre- and post-experiment.

Experiment #11 is performed in the laboratory component of Chemistry 123, the second semester of the first year introductory chemistry course at the University of British Columbia. The course is required by all students in the faculty of science, as well as some in other faculties, and is comprised of > 1600 students, of which approximately 40% are male and 60% are female, and 35-45% identify as EFL (English First Language).

Results

Pre- and Post-quizzes scores (by laboratory section)

<table>
<thead>
<tr>
<th></th>
<th>Pre</th>
<th>Post</th>
<th>Avg (%)</th>
<th>Pre Avg (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre</td>
<td>post</td>
<td>pre</td>
<td>post</td>
<td>pre avg</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>59.2 ± 1.1</td>
<td>67.9 ± 1.9</td>
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</tr>
<tr>
<td>2</td>
<td>1</td>
<td>60.6 ± 1.6</td>
<td>66.6 ± 1.2</td>
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</tr>
<tr>
<td>3</td>
<td>1</td>
<td>61.0 ± 0.9</td>
<td>69.9 ± 1.3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>60.5 ± 1.1</td>
<td>67.8 ± 1.4</td>
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Average score improved from 60.3% (pre) to 68.5% (post)

Average Learning Gain: 0.237

Data Collection

- Pre/post-lab quizzes administered 2 weeks prior and 2 weeks after the experiment
- Quizzes split into 2 versions to reduce length
  - questions addressing the same LG kept together
  - 50% students received the same version of post-quiz and 50% the alternate version to examine “pre-testing effect”
- Quiz scores and learning gains calculated
- In-lab observations assessed technique and safety LG’s

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References

References


Experiment #11: Electrochemistry: Galvanic Cells and the Nernst Equation

Learning Goals1

Primary

Concepts:
- Lab Safety
- Reference Electrodes
- Galvanic Cells
- The Nernst Equation

Experimental Procedure2

Part I: Set up Galvanic cells; create and use an electrochemical series to predict voltages of other cells; test predictions.

Part II: Make calibration curve of E CuZn vs. Log[Cu2+]3; Use with the Nernst Equation to calculate the concentration of an unknown.

Pre- and Post-Scores by LG Concept

<table>
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<tr>
<th></th>
<th>Electrochemical Potential</th>
<th>Students’ understanding of oxidation and reduction concepts (q5) and balancing equations (q7) has improved, but understanding of electrochemical potential has remained low (q4)</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td>Students’ ability to use galvanic cell notation has improved (q8), however their understanding of the redox reactions that occur in Galvanic Cells, and how Galvanic Cells work, did not change (q9).</td>
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</tbody>
</table>

The Nernst Equation

Understanding:
- effects of adding water on voltage (q3) improved but is still low
- that water affects concentration (q9), but have trouble extending this to its affect on voltage
- effects of precipitating out a solute on voltage (q10) remained the same, and is significantly higher than the effects of water (q3)
- equilibrium (q4, q12) remained consistent, effects of precipitation (q12) is better understood than effects of adding water (q4)
- effect of the meaning of Q and of its effect on the Nernst equation (q5,6,7,13,14,15) either improved or remained consistent

In-Lab Observations

Safety procedures are followed (correct disposal of waste). TA instructions strongly affected students’ following of experimental procedures, such as rinsing and using tweezers.

Summary

- Students’ scores improved from pre- to post-quiz, average learning gain of 0.237
- No pre-test effect apparent
- Improvement seen in redox, balancing eq.s, Galvanic cell notation, use of a reference electrode, and Q in the Nernst Equation
- Little improvement in electrochemical potential, Galvanic cells, concentration in the Nernst Equation, and definition of a reference electrode

Future Work

- Further statistical analysis
  - to confirm absence of pre-test effect
  - to test presence of differences between groups/sections
- Expert validation of questions
- Cross-tabulation of student responses to examine where individual answers changed
- Post-quiz student validation interviews
- Comparison to LG achievement from previous year