Evaluation of Learning Gains in CHEM 123 students performing
Experiment 12 – pH in Blood

1Chemistry Department, Carlsbad Wieman Science Education Initiative, University of British Columbia, Vancouver, BC, V6T 1Z1, Canada
2Chemistry Department, University of British Columbia, Vancouver, BC, V6T 1Z1, Canada
3Department of Chemistry and Biochemistry, Northern Arizona University, Flagstaff, AZ, 86011, USA

Introduction
• Student achievement of Learning Goals (LG’s) in Experiment 12 - pH in Blood.
  • 1st year undergrad CHEM 123 students (~1600 students)
  • Previously developed survey questions reviewed by experts, and then further modified during Fall 2010.
  • Exploratory project examined maintenance of laboratory notebooks from years 2008-2010.

Research Design and Data Analysis
• Experts’ feedback used to iteratively refine survey
• Surveys further validated with broad sample of students.1
• Questions split into 3 versions of the survey – 9A, 9B and 10.
  • 9A differs from 9B in Qs. 11-13 (9A has counters inserted in answer choices while 9B doesn’t) & 19-20 (9A has “strong acid” in the stem of Q19-20, 9B has “strong base” in the stem of Q20).
• Data analyzed in Excel using ANOVA, Paired t-test, F-test and t-tests.
  • p<0.05 considered significant and p>0.05 not significant.
• Weeks 2, 3, 4 & 8 are PRE surveys and Weeks 6, 9, 10, 11, 12 are POST surveys –
  • PrePost for Weeks 2&6 were done before students performed the lab to determine if learning could be attributed to the experiment.
  • Week 9 was a “blind” Post to determine if there was a “Pre-test effect”.

Quiz Administration and Processing
• Students “randomly” received Survey Versions 9A/9B or 10 for PRE Weeks and relabeled with same version during POST Weeks.

Results: Average PRE/POST Scores

<table>
<thead>
<tr>
<th>Survey</th>
<th>Total Responses</th>
<th>PRE (%)</th>
<th>POST (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9A PRE</td>
<td>367</td>
<td>64.84%</td>
<td>71.63%</td>
</tr>
<tr>
<td>9B PRE</td>
<td>487</td>
<td>66.25%</td>
<td>73.01%</td>
</tr>
<tr>
<td>10 PRE</td>
<td>870</td>
<td>59.34%</td>
<td>66.25%</td>
</tr>
</tbody>
</table>

Of the 2074 responses, 643 valid PRE Surveys and 1081 valid POST Surveys were analyzed for learning gains.

Learning gain scores were calculated by normalized change.2 Standard error was used to estimate the error associated with calculating average gain scores.

Results: Pre-test effect
• Week 9 was a BLIND POST used to compare against the “regular” POSTS to check for any pre-test effect.
  • ANOVA found NO significant difference (p>0.05) in WEEK 9 – BLIND POST versus those that also did PRE Surveys (WEEKS 10, 11, 12&13)

Survey 9B:
  • Week 9: Average = 65.87 ± 2.62%
  • Weeks 10,11,12&13: Average = 61.37 ± 2.12%

Survey 10:
  • Week 9: Average = 66.25 ± 2.62%
  • Weeks 10,11,12&13: Average = 66.04 ± 1.68%

Exploratory Project: Lab Notebooks
• There is an apparent improvement in making observations from year 2008 to 2010.
  • In 2008, ~1/4 of students properly recorded observations.
  • In 2010, this improves to >3/4 of students.

Conclusions
• Each survey had low-moderate learning gains.2
  • Survey 9A average gain score = 0.24 or 24% of total possible learning
  • Survey 9B average gain score = 0.23 or 23%
  • Survey 10 average gain score = 0.44 or 44%
• The absence of a pre-test effect was confirmed through comparing Week 9 Blind Post responses to the those who also answered PRE Surveys.
• While pre/post test before completion of experiment showed no gain, Week 8 also did not have an increase in concepts covered on surveys 9A and 9B. However, there is a significant learning gain for Week 8 on survey 10.
• The significant difference in understanding of strong base vs. strong acid application to buffer solutions should be explored further.
• Apparent improvement in Observation section of Lab Notebook from years 2008-2010.

Acknowledgements
• Participants who provided feedback and answered the survey.
• Anne Thomas and Angela Anganipito for logistical support during quiz administration in labs.
• TAs for handing out and collecting quizzes during lab.
• Grace Wood of CWSEI for providing assistance in processing Scannors.
• CWSEI and UBC Chemistry Department for funding and equipment.

References