



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

S. D'souza^a, J.M. Duis^b, L.L. Schafer^a, J. Stewart^a, I. Hoogendoorn^a, B. Cruickshank^c, N. Mah^a, S. Nussbaum^a

^aChemistry Department, Carl Wieman Science Education Initiative, University of British Columbia, Vancouver, BC, V6T 1Z1, Canada

^bChemistry Department, University of British Columbia, Vancouver, BC, V6T 1Z1, Canada

^cDepartment 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 counterions inserted in answer choices while 9B doesn't) & 19-20 (9A has "strong acid" in the stem of Q19-20, but 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 –
 - Pre/Post 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 retested with same version during POST Weeks.

| | Total Response | Response rate | 1st-Year | Male | Female | Canadian citizen | English is 1st Language |
|-----------|----------------|---------------|----------|--------|--------|------------------|-------------------------|
| Survey 9A | 367 | 21.29% | 67.79% | 43.37% | 56.63% | 78.49% | 32.21% |
| Survey 9B | 487 | 28.25% | 66.12% | 36.99% | 63.01% | 83.24% | 33.88% |
| Survey 10 | 870 | 50.46% | 66.89% | 42.09% | 57.91% | 82.29% | 33.11% |

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.

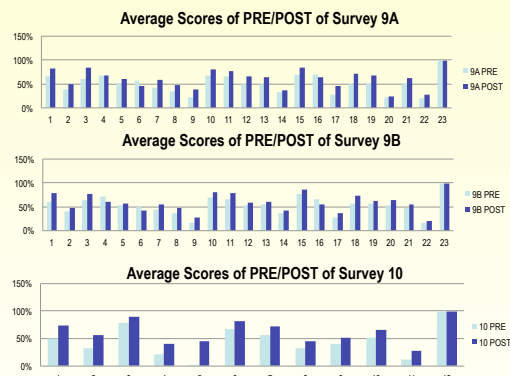
Acknowledgements

- Participants who provided feedback and answered the survey.
- Anne Thomas and Angelo Ariganello 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 Scantrons.
- CWSEI and UBC Chemistry Department for funding and equipment.

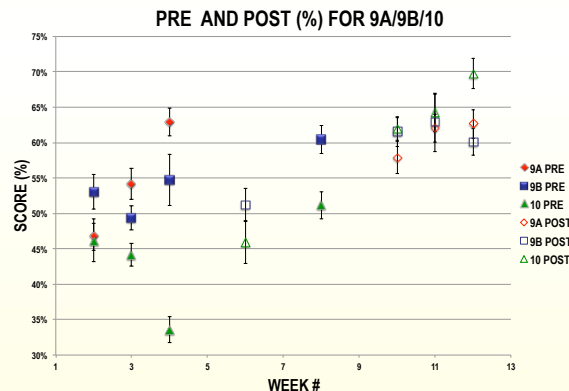
References

1. Barreira, J., Perkins, K. K., Adams, W. K., & Wieman, C. E. Modifying and validating the Colorado learning attitudes about science survey for use in chemistry. *Journal of Chemical Education*. 2008, 85, 1435-1439.
2. Marx, J. D.; Cummings, K. *American Journal of Physics*. 2007, 75, 87-91.
3. Towns, M. H. *Journal of Chemistry Education*. 2010, 87, 91-96.

Results: Average PRE/POST Scores



- Upon comparing 9A and 9B, X^2 shows **no difference** in understanding when counterions are given.
- However, a significant difference was found in understanding application of strong base vs. acid to a buffer solution.



Note:

- Learning gains between Week 2 & 6 was not significant which suggests any learning in the following weeks were attributed to the experiment.
- All normal weeks had SIGNIFICANT pre/post learning gains except for Week 8.
- During Week 8, students would have completed Acid/Base in the lecture and had a midterm covering the same material. Which suggests that the learning for the concepts covered on surveys 9A and 9B, were not further increased by the experiment at this point.

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 = $65.87 \pm 2.86\%$
- Weeks 10, 11, 12 & 13: Average = $61.37 \pm 1.21\%$

Survey 10:

- Week 9: Average = $66.25 \pm 2.62\%$
- Weeks 10, 11, 12 & 13: Average = $66.04 \pm 1.68\%$

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.