



# Investigation of student attitudes and understanding in general chemistry

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## Research Question and Hypothesis

Does substituting one inquiry experiment, in place of the traditional verification experiment, have an effect on student attitudes and understanding on the subject of stoichiometry in the first semester General Chemistry at UW-Eau Claire.

Our hypothesis was that students who were given an inquiry-based laboratory experiment would have measurable improvements in understanding and attitude versus the students given a traditional laboratory experiment.

## Methodology

This study was carried out during Fall 2014 in a first semester General Chemistry course for science majors, nursing majors, and other students (as a general education course).

- A total of 98 students were enrolled in the course. All students attended the same lectures and took the same exams.
- Each student enrolled in one of four lab sections taught by the lecture instructor (Theisen). Two of the four lab sections were randomly selected to be the inquiry group or treatment group. The other two sections were the control group.
- The control group and the inquiry group did nine identical laboratory experiments over the course of the semester.
- The only curriculum component that was different for the control and inquiry groups was one experiment on the topic of stoichiometry, which occurred during the sixth week of the fifteen-week semester.

## Timeline of project

Part	Description	Week of Semester
1	Pre-treatment survey (Time 1)	2
2	Treatment experiment	6
3	Post-treatment survey (Time 2)	6
4	Post-treatment quiz	7
5	Post-treatment Exam#2	10
6	Post-treatment Exam#3	14
7	Post-course survey (Time 3)	15
8	Post-treatment Final exam	16
9	Post-course overall grade	16

## Assessment of Attitude

The Attitude towards the Subject of Chemistry Inventory (ASCI V2) was the survey used to assess students' attitude toward chemistry at three times during the fifteen-week semester.

### CHEMISTRY IS

1	Easy	1	2	3	4 middle	5	6	7	hard
2	Complicated	1	2	3	4	5	6	7	Simple
3	Confusing	1	2	3	4	5	6	7	Clear
4	Comfortable	1	2	3	4	5	6	7	Uncomfortable
5	Satisfying	1	2	3	4	5	6	7	Frustrating
6	Challenging	1	2	3	4	5	6	7	Not challenging
7	Pleasant	1	2	3	4 middle	5	6	7	Unpleasant
8	Chaotic	1	2	3	4	5	6	7	Organized

## References

- UW-Eau Claire CHEM 103 Lab Manual, Fall 2014. Stoichiometry #1 "Determining the Mole Ratios in a Chemical Reaction." and Stoichiometry #1 Alternate: "The Reaction of Zinc and Iodine." 2014. (2) Wheeler, L.; Bell, R. Open-Ended Inquiry. *Sci. Teach.* **2012**, 32–39. (3) Bauer, C. F. Attitude toward Chemistry: A Semantic Differential Instrument for Assessing Curricular Impacts. *J. Chem. Educ.* **2008**, 85 (10), 1440–1445. (4) Xu, X.; Lewis, J. E. Refinement of a Chemistry Attitude Measure for College Students. *J. Chem. Educ.* **2011**, 88 (5), 561–568. (5) Theisen, R. Was Approved to Work on This Project by the UW-EC Institutional Review Board (IRB) for the Protection of Human Subjects under the Category of Exempt (IRB Number THEISERM6702012), August 2012. (6) Field, A. *Discovering Statistics Using SPSS*, Third Edition.; Sage Publications Ltd: London, 2009. (7) Bruck, L. B.; Towns, M. H. Preparing Students To Benefit from Inquiry-Based Activities in the Chemistry Laboratory: Guidelines and Suggestions. *J. Chem. Educ.* **2009**, 86 (7), 820–822. (8) Cacciatore, K. L.; Sevan, H. Incrementally Approaching an Inquiry Lab Curriculum: Can Changing a Single Laboratory Experiment Improve Student Performance in General Chemistry? *J. Chem. Educ.* **2009**, 86 (4), 498–505. (9) Banchi, H.; Bell, R. The Many Levels of Inquiry. *Sci. Child.* **2008**, 26–29.

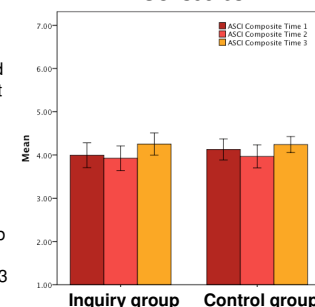
## Results

Using IBM SPSS Statistics, a software package used for statistical analysis, the composite ASCI V2 scores were compiled, tested for reliability using Cronbach's alpha and processed for statistical significance by the independent samples *t*-test and a paired *t*-test. Composite attitude score means and standard deviations were also evaluated. The graded assignment scores post-treatment were processed for statistical significance by the independent samples *t*-test and the means and standard deviations of these assessments were evaluated. Scores from Exam #1 (given pre-treatment) were analyzed as a covariate (an independent variable) to identify group inequalities. There were no group inequalities found.

### Attitude Survey Results

- The pre-treatment composite score for the inquiry group and control group were equal in terms of initial attitude toward chemistry and both groups had a neutral attitude (halfway between 1 and 7).
- The post-treatment composite scores for both groups decreased from Time 1 to Time 2, but the final attitude composite scores, at the end of the semester had rebounded (Time 3).
- The two experimental groups' composite scores did not differ significantly at Time 1, Time 2 or Time 3.
- Using a series of paired *t*-tests, we found that both groups' composite attitude scores increased significantly from Time 2 to Time 3 ( $p=.038$  for the inquiry group and  $p=.015$  for the control group), which is the time frame associated with the treatment lab to the last laboratory of the semester. In addition, the inquiry groups attitude also significantly increased from Time 1 to Time 3 ( $p=.023$ ).
- The control groups' composite scores did not change over the course of the semester or from Time 1 to Time 2 ( $p>.05$ ).

Inquiry vs Control Composite ASCI scores

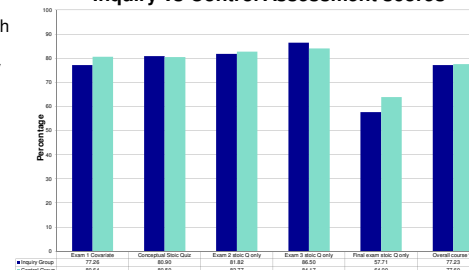


### Exam and Quiz Results

To measure understanding of stoichiometry, both groups were given four assessments on conceptual and calculation-based stoichiometry material after the sixth-week of the semester.

- Statistical analysis of data on student performance on assessment measures indicated no significant differences between the groups.
- This indicates the inquiry lab experiment nor the control experiment effected student outcomes for the course and it is more likely another factor that contributes to the overall course percentage.

Inquiry vs Control Assessment scores



## Evaluation of project's success & Future work

- We found that substituting a confirmatory inquiry experiment with a structural inquiry experiment did not yield a significant advantage or disadvantage to student academic performance or student attitude toward chemistry in the groups studied.
- One way to make inquiry-based laboratory experiments more successful in general chemistry labs would be to scaffold students' learning from a structured to an open inquiry lab over the course of the semester as described in a recent report.<sup>9</sup> But, further research is needed to determine the amount of inquiry-based laboratory experiments that will provide students with an enriching experience while not creating cost or instructing issues.
- The second iteration of this teaching and learning project is currently underway to study the effect of online versus face-to-face teaching on student attitude and understanding on the subject of inorganic chemistry.

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