

Flipping the General Chemistry Laboratory Lecture: Increasing Student Engagement By Enhancing Self-Directed Learning

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Project Overview

Strengthening instruction in STEM fields can benefit student learning as well as foster positive attitudes towards the sciences. This project tries to answer the question whether there is a measurable difference in understanding of and attitudes towards chemistry of two groups: students who complete a General Chemistry course where the laboratory lecture is in a flipped format and students who complete a General Chemistry course where the laboratory lecture is in a traditional lecture format.

In this study, flipped and traditional student attitudes and understanding will be assessed by several quantitative and qualitative measures. A published, validated and reliable attitude survey on the subject of chemistry will be given to student participants (the ACSI V2) at the beginning and at the end of the course. To quantitatively assess student understanding of General Chemistry of all groups, standardized final exam scores were examined and statistically analyzed.



Figure 1 (Seery)

Goals

- Gather information about the impact of flipped or traditional teaching modes on student learning
- Measure student understanding of General Chemistry
- Measure student attitudes towards the subject of chemistry

Hypothesis

Our hypothesis is that students who are enrolled in the flipped curriculum course will have a higher measurable outcome of understanding of and attitudes towards chemistry.

Population Studied

At the University of Wisconsin – Eau Claire, two combined lecture and lab sections of a first-term General Chemistry course were studied.

Fall 2014 – General Chemistry I (CHEM 103) – control section

Fall 2016 – General Chemistry I (CHEM 103) – flipped section

Professor Theisen was the lecture instructor of both courses.

The flipped and control courses were designed to achieve equivalent expectations.

Statistical Analysis

Using IBM SPSS Statistics, a software package used for statistical analysis, the two subscales IA and ES from the ASCIv2 survey were compiled and processed for statistical significance by the independent samples t-test. The t-test measures the degree to which two groups/experiments have the same average value. When $p > 0.05$, statistical analysis indicates that the difference between groups is not significant. The American Chemical Society standardized final exam scores for General Chemistry (with a raw score out of 70) were processed for statistical significance by the independent samples t-test. The means and standard deviations of this assessment were also evaluated as well as final course percentage.

Why Flipped Learning?

A flipped course combines the best features of face-to-face teaching with those of the online learning environment. This learning style is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment.

Flipped Learning Involves:

1. Flexible learning environments
2. Student-centered classrooms
3. Just-in-time teaching
4. More intentional instruction

While flipped lectures courses have appeared throughout the undergraduate curriculum, flipped laboratory experiences are more rare.

Timeline of Events

Part	Description	Data Collection Fall 2014 and Fall 2016
1	Pre-Course Attitude Survey	ASCIv2 attitude survey was given to participating students on the 6th week of the course. Bonus points were awarded for participation.
2	Lab and Lecture Delivery	All groups covered the same topics in lab and lecture and were given similar assessments, but differed in lab lecture content delivery mode (flipped or traditional).
3	Post-Instruction Final Exam	The same standardized final exam was given to all students
4	Post-Course Attitude Survey	ASCIv2 attitude survey was given to participating students after the 15 th week of the course. Bonus points were awarded for participation.

Assessment of Attitude

Attitudes are an important non-cognitive factor in science literacy that science educators emphasize. The assessment of both academic achievement and non-cognitive values are an essential component of science education.

[The Attitude Toward the Study of Chemistry Survey \(ASCIv2\) is a semantic differential survey created by Xu and Lewis \(2011\).](#)

- ❖ Items 1, 4, 5 and 7 needed to be re-coded in order for higher scores to represent positive aspects of students' attitudes.

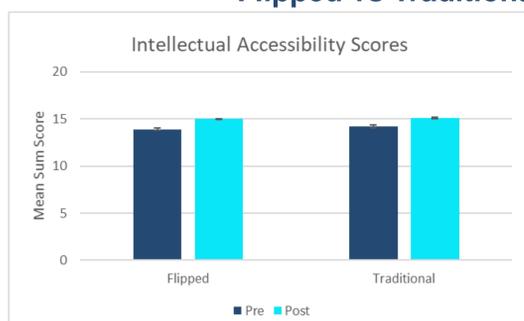
- ❖ The ASCIv2 has two subscales, intellectual accessibility (IA) and emotional satisfaction (ES).

- ❖ Items 1, 2, 3 and 6 load on the IA subscale and items 4, 5, 7 and 8 load on the ES subscale.

CHEMISTRY IS									
1	Easy	1	2	3	4	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	5	6	7	Unpleasant
8	Chaotic	1	2	3	4	5	6	7	Organized

Data and Results

Flipped vs Traditional Pre and Post ASCIv2



- ❖ Items 1, 2, 3 and 6 were summed to represent Intellectual Accessibility (total possible 4 to 28) and items 4, 5, 7 and 8 were summed to represent Emotional Satisfaction (total possible 4 to 28).

- ❖ When comparing the pre- and post-IA scores for the students in the traditional group and the flipped group, both IA scores increased. However, neither of these values are significant ($p = 0.105$ for traditional IA, $p = 0.137$ for flipped IA), because of this, we cannot reject the null hypothesis.
- ❖ Students in both the flipped and traditional groups showed comparable intellectual accessibility sum scores at the beginning and at the end of the semester.

- ❖ When comparing the pre- and post-ES scores for students in the flipped group, there is a decrease in ES sum score. The p value found is 0.583. This value is not significant, and because of this, we cannot reject the null hypothesis. In comparing the pre- and post-ES scores in the traditional group, there is an increase in ES sum score. This increase is statistically significant where $p = 0.041$, which means we can reject the null hypothesis.
- ❖ Students in the traditional course show a statistically significant increase in emotional satisfaction, where students in the flipped group show no net change in emotional satisfaction.

Final Exam Average and Final Course Average

	ACS Raw Score Out of 70	Course Grade Percentage
Traditional Group Mean	32.8	77.9
Std. Dev.	8.0	5.5
N	87	87
Flipped Group Mean	33.3	83.6
Std. Dev.	7.8	12.9
N	65	67

- ❖ The average final exam score (out of 70) for the traditional group is 32.8 and for the flipped group is 33.3. There was no significant difference in final exam scores between the two groups ($p = 0.68$). We can say we did no harm to students understanding of chemistry by flipping the laboratory lecture.

- ❖ The average course percentage for the traditional group was 77.9% and for the flipped group the average course grade percentage was 83.6%. There was a significant difference in course grade percentage ($p = 0.006$) which indicates that students in the flipped classroom did better overall in the course than the traditional group.

- ❖ There was a significant difference ($p < 0.001$) between the flipped and traditional for the overall course percentage and there was not a significant difference between the raw scores between the two group

Attitude and Final Exam Score

Both Emotional Satisfaction and Intellectual Accessibility (measured by the post-ASCIv2 survey) at the end of the semester was significantly correlated with ACS exam raw score, $r = .48$ for ES and $r = .44$ for IA, for the flipped group (all $ps < .001$).

Both Emotional Satisfaction and Intellectual Accessibility (measured by the post-ASCIv2 survey) at the end of the semester was significantly correlated with ACS exam raw score, $r = .11$ for ES and $r = .16$ for IA, for the traditional group (all ps NOT $< .001$).

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