Effect on Retention and Final Grades of Concurrent Enrollment in Physical Science Lecture and Laboratory Courses

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Abstract

Collegiate physical science lectures and laboratories are often offered as separate courses, and students may not be required to concurrently enroll in both courses. Here, we examined the impact of concurrent vs. nonconcurrent enrollment on withdrawal rates from and final grades in **general chemistry and physics lectures** at University of Michigan using multiple linear and binary logistic regression analyses, respectively. We found that concurrent enrollment in general chemistry lecture and laboratory:

1) positively impacts retention in the lecture by an average of 225%,
2a) positively impacts final lecture grades for all students by up to 0.21 grade points, and
2b) the weakest students, as identified by university-level math and chemistry placement exam scores, receive the most benefit from concurrent enrollment in terms of final lecture grades.

Interestingly, concurrent enrollment had no effect on final grades or withdrawal rates in general physics.

Rationale

The literature provides support for the laboratory experience in learning science (NSTA, 2007; Reid & Shah, 2007), but little has been published on the relative *timing* of the lecture and lab (Matz, 2011), i.e., is it important to concurrently enroll?

Matz, R. L., Rothman, E. D., Krajcik, J. S., & Banaszak Holl, M. M. (2011). Does concurrent enrollment in lecture and laboratory impact student performance and retention? Submitted to the *Journal of Research in Science Teaching*.
National Science Teacher' Association. (2007). NSTA position statement: Integral role of laboratory investigations in science instruction. Retrieved July 6, 2010, from http://www.nsta.org/about/positions.aspx.
Reid, N., & Shah, I. (2007). The role of laboratory work in university chemistry. Chemistry Education Research and Practice, 8(2), 172-185.

Methods

General Chemistry
N ≈ 10,000
Fall 2002 – Spring 2008

General Physics
N ≈ 18,000
Fall 2002 – Winter 2009

Course Structures

Traditional lecture & lab
CSP lecture & traditional lab
Studio lecture & lab

Noncalculus-based lecture & lab
Calculus-based lecture & lab

Regression Analyses

Multiple linear and binary logistic regressions were used to investigate the final grade and withdrawal rate, respectively.

Covariates Used in Regression Analyses

- Enrollment status (concurrent or nonconcurrent)
- Age, gender, high school GPA, and SAT score
- Cluster number based on math and chemistry placement exams
- Interaction of enrollment status and cluster number

Results

1) Concurrent enrollment in general chemistry lecture and laboratory positively impacts retention in the lecture by 225% ($R^2 = 0.18$).

Table 1

Covariates	*B*	*SE B*	*Exp(B)*	*p*
Constant	2.70	0.15	14.91	0.00
(a) Factor score of GPA and SAT	0.47	0.06	1.61	0.00
(b) Cluster number	0.75	0.12	2.12	0.00
(c) Enrollment status	0.81	0.20	**2.25**	0.00
(d) Interaction of (b) and (c)	0.14	0.18	1.15	0.43

2a) Concurrent enrollment in general chemistry lecture and laboratory positively impacts final lecture grades by up to 0.21 grade points ($R^2 = 0.31$).

2b) The weakest students, as identified by math and chemistry placement exam scores, receive the most benefit from concurrent enrollment in terms of final lecture grades.

Table 2a

Covariates	*B*	*SE B*	*t*	*p*
Constant	2.37	0.02	110.1	0.00
(a) Factor score of GPA and SAT	0.28	0.01	36.7	0.00
(b) Cluster number	0.25	0.01	21.3	0.00
(c) Enrollment status	**0.21**	0.03	7.7	0.00
(d) Interaction of (b) and (c)	**-0.04**	0.01	-2.9	0.00

Table 2b

Cluster number	Δ Grade units
0	0.21
1	0.17
2	0.13
3	0.09

3) Concurrent enrollment had no statistically significant effect on final grades or withdrawal rates in general physics lectures or laboratories.

Table 3

	Noncalculus track		Calculus track	
	1st sem	2nd sem	1st sem	2nd sem
	N ~ 5255	N ~ 4060	N ~ 7861	N ~ 6246
Concurrent students have higher final lecture grades than nonconcurrent students by _____ grade points on average. (*p* value)	+0.01 (0.75)	+0.04 (0.33)	-0.00 (0.97)	+0.00 (0.91)
Concurrent students are _____ more likely to be retained in the lecture course than nonconcurrent students on average. (*p* value)	133% (0.29)	55% (0.14)	87% (0.54)	133% (0.29)

Limitations

We intended to analyze each student's first experience in the lecture and laboratory; however, in the chemistry data set we encountered two limitations:

1) Students could have enrolled prior to Fall 2002.
2) Lecture data were collected only for fall terms; students could have enrolled for the first time during a winter or spring term.

We requested the physics data set so as to avoid the second limitation, however the first limitation still applies.

Discussion

Decades of studies have been published concerning improving student performance and retention, but these data show that in general chemistry, significant increases in performance and retention can be effected by relatively simple actions on the part of students and university. The results may be related to the structure of the laboratory course, as the traditional chemistry lab actually exemplifies many principles that have been shown to support effective science learning environments. In particular, the heavy emphasis on collaborative work in combination with metacognitive processes and peer interaction may be the most important causal elements related to the outcomes described here. Across many years and disciplines, collaborative work has been shown to enhance student achievement, retention, and attitudes, among other outcomes. In the physics data, though concurrent enrollment was found to have no impact on final grades or retention, we did find a robust effect of gender on final grade, namely that males earned 0.12 – 0.30 higher final grade points than females on average in all four physics lecture courses studied. However, these effects are already well-known in physics education literature.

Conclusion

These data provide important results for consideration by curriculum advisors and course planners at universities that do not require concurrent enrollment in general chemistry lecture and laboratory, as well as for high schools where laboratory experience has been diminished or even eliminated altogether. Also, it would be interesting to investigate the differences in course structure and pedagogical technique between Michigan's general chemistry and physics courses.

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