Factors that influence learning gains in inquiry-based laboratory courses

Lawrence S. Blumer[1] and Christopher W. Beck[2]
[1]Morehouse College and [2]Emory University, Atlanta

Introduction

Inquiry-based learning in laboratory courses is often thought to lead to increased learning gains as compared to traditional approaches. However, previous studies that have examined learning gains in inquiry-based laboratory courses have done so in single courses at single institutions. To achieve a broader perspective on the factors that influence learning gains in inquiry-based laboratory courses, we used a standard pre-test/post-test approach with students in laboratory courses from five different colleges and universities in courses ranging from introductory biology to advanced courses for majors. This study was conducted as part of an assessment of newly developed guided-inquiry laboratory protocols using the bean beetle, *Callosobruchus maculatus*, model system.

Predictions

We made the following predictions about relationships between faculty instructional practice, reported by the faculty, and student perceptions, confidence, and performance:

Faculty instructional practices will be reflected in student perceptions of instructional practices.

Faculty instructional practices that are more inquiry-based will result in:
- increased student confidence
- increased understanding of the nature of science
- improved scientific reasoning

compared to faculty instructional practices that are less inquiry-based.

Evaluation Methods

- **Faculty Instructional Practices**: faculty complete surveys on their instructional practices prior to the workshop and following teaching using bean beetles.
- **Student Assessment**: students were assessed on self-efficacy, understanding of the nature of science, and scientific reasoning skills using pre-test/post-test with validated instruments.

Student Perceptions of Instructional Practices

An end of course survey of students was performed using the same questions that were asked of faculty. Survey items addressed five Instructional Practice Constructs: Assessment of Learning, Authentic Activities, Facilitated Learning, Complex Tasks, and Inquiry-based Learning.

Faculty Instructional Practices

- Overall, little change in faculty instructional practices due to attending the workshops, based on faculty participants from 2009
- Faculty did report significant positive changes in the degree to which students engage in work focusing on a product significant to them and do work requiring a significant investment of time and intellectual resources (Mann-Whitney U, $N_a = 18$, $N_b = 12$, $p<0.05$ for both categories).
- Faculty and student perceptions of instructional practices were highly correlated across all items ($r=0.47$, $p<0.01$) when pooling across institutions.
- For each of the five institutions included in the sample, faculty and student perceptions were positively correlated, but to differing degrees ($r=0.26$ – $r=0.70$).

Student Assessment

Sample: 6 of 9 institutions from the 2009 cohort of our Bean Beetle Curriculum Development Network, plus Morehouse and Emory

Instruments: Self-efficacy[1], Nature of Science[2], Scientific Reasoning[3] (significant gain in Self-efficacy, paired-t = 15.8, N=472, $p<0.0001$, Figure 1)

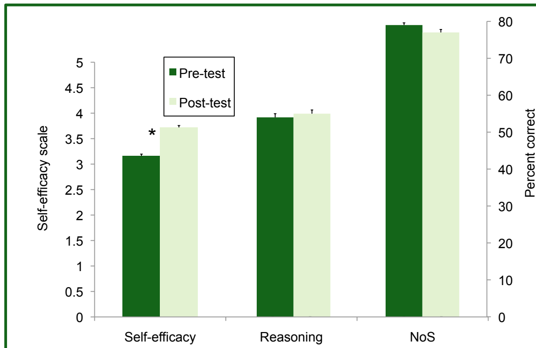

Figure 1: Change in student confidence and ability

Predictors of Student Confidence and Performance

Student confidence was best predicted by student perceptions of instructional practices and their pre-test confidence. However, positive perceptions of instruction for Inquiry-based Learning were negative predictors of confidence (Table 1).

Understanding the Nature of Science was best predicted by course level, student perceptions of Authentic Activities, and pre-test score (Table 1).

Scientific Reasoning was best predicted by college major (STEM or non-STEM), number of previous laboratory courses, student perceptions of instructional practices and pre-test score (Table 1).

Table 1. Factors influencing student confidence, understanding the nature of science, and scientific reasoning skills.

		Post-test scores		
	Predictor variables	**Confidence**	**Nature of Science**	**Scientific Reasoning**
Student Characteristics	College Major (0 = non STEM, 1=STEM)			0.088
	Number of previous laboratory courses taken			0.170
	Course Level (0 = lower, 1=upper)		0.097	
Students' Perceptions of Instructional Practices	Authentic Activities	0.171	0.137	0.126
	Facilitated Learning			0.086
	Complex Tasks			-0.174
	Inquiry-based Learning	-0.187		
	Assessment for learning	0.207		
Prior knowledge	Pre-test score	0.494	0.392	0.570

Values are standardized Beta weights for the best minimizing AIC model.

References

[1]Champagne, A. B. 1989. Defining scientific literacy. Educational Leadership 47:85-86.

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[3]Murcia, S. and R. Schibeci. 1999. Primary student teachers' conceptions of the nature of science. Int. J. Sci. Ed. 21:1123-1140

Acknowledgements

This project supported by NSF DUE-0815135, and DUE-0814373. We thank our faculty participants in the BBCDN and their students for participating in this project.