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A Comparison of Experimental Designs for Assessment and Research in Higher Education

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Abstract. Assessment continues to rise in importance along with the scholarship of teaching and learning. Educators must, therefore, choose among a range of experimental designs to make these quantitative measurements of student learning. We compared three different study designs for an assessment of embedding sustainability across the campus: comparing results to a pre-determined goal, pre-semester vs. post-semester survey scores without a control group, and pre-semester vs. post-semester survey scores with a control group. Patterns in student success varied among the study designs, with pre-post with a control being the most reliable results, but comparing student knowledge and appreciation of sustainability to the pre-set goals was also valuable. Ours are the first results we are aware of to make such a direct comparison, and should be valuable to teachers and researchers as they seek to design assessment as well as teaching and learning research projects. We recommend that educators employ both the pre-post with control design along with comparing learning to a goal whenever possible when conducting assessment or education research.

Keywords: Education Research; Research Design; Scholarship of Teaching; Sustainability; Undergraduate Education

Introduction

Assessment of educational practices is becoming more and more important to college teachers.In one form, assessment is required for accreditation of the institution (Lubinescu, Ratcliff, & Gaffney, 2001;Middle States Commission on Higher Education [MSCHE], 2006;New England Association of Schools and Colleges [NEASC], 2012), and leads to important school-wide improvements based on those results (Scrivens, 1997).In another form, professors are increasingly encouraged to assess their own teaching and to treat it as a form of scholarship (Boyer, 1990;Richlin& Cox, 2004).These efforts give further credibility to the art of teaching and improve practices for the benefit of students, teachers, and society (Trigwell, Martin, Benjamin, & Prosser, 2000). In order to conduct assessment effectively, the teacher needs to consider the range of designs that are available and appropriate based on the item being assessed (Wiersma, 1991).These experimental designs range from those that include pre- and post-tests along with control groups to ones with a post-test only (Wiersma, 1991).The myriad designs yield a range of

data that allow the teacher to know different things about their students and their learning.Comparing these approaches allows teachers to see the benefits and limitations of the approaches.
The objective of this study was to compare three different experimental designs for a scholarship of teaching and learning project to reveal the strengths and weaknesses of each approach.We analyzed data from pre- and post-test with control, pre- and post-test alone, and post-test designs within a single project to make this comparison (Tessier et al.,2013).

Methods

Conduct of this study was approved by SUNY Delhi's Institutional Review Board before the onset of data collection.We engrained the concept of sustainability across four courses (Architecture, Biology, Business, and Humanities disciplines), and three non-curricular activities (community service, learning center, and residence life areas) on the SUNY Delhi campus.With each course in which sustainability was embedded, we paired a similar course in which sustainability was not embedded as a control.We delivered a pre-semester and post-semester survey to all of these students assessing their understanding of the concept of sustainability and if they felt the concept was important to the course and their career.We used data from the control courses to compare the results for students who did and did not engage in the non-curricular activities in the project.Details of the approach can be seen in Tessier et al. (2013).

This approach allowed us to compare three designs for the experiment and data analyses.All statistical tests were conducted using Minitab version 16 (Minitab, Inc., State College, PA USA) at $\alpha = 0.05$.First, we compared the change in students' knowledge of sustainability and their views on its importance between treatment (those in the class or activity that infused sustainability) and control groups (students who were not in a class or activity that infused sustainability) using t-tests.Second, we used t-tests to compare the pre-semester and post-semester scores for students' understanding of and views on sustainability within the group of students who took a course or participated in an activity that infused sustainability.Third, we compared the average student score within treatment groups for understanding of sustainability and views on sustainability to a pre-set goal (knowing 2 or more tenets of sustainability and feeling that sustainability was important to the course and the students' career).

Results

*Pre- and Post-Semester with Control:*In the pre-post with control design, we found that the treatment courses helped students understand the concept of sustainability more than the control courses in every case (Table 1).In only one pairing did the treatment course increase the students' perception of the relatedness of sustainability to the course more than the control (Table 1), and in none of the course pairings did the treatment course increase the students' perception of the relevance of sustainability to their careers more than the control course (Table 1).In two of the three non-curricular areas, students who participated in activities increased their understanding of the tenets of sustainability more than those who did not participate (Table 2).In none of the non-curricular areas did participation in the activities increase students' perception of the importance of sustainability to their careers more than non-participation (Table 2).

*Pre- vs. Post-Semester:*In comparing pre- and post-semester understanding of the tenets of sustainability, every course led to a significant increase (Table 3). In half of the courses, there was also a significant increase in the perception that sustainability was important to the course (Table 3). In none of the courses was there a significant increase in students' perception of the relevance of sustainability to their careers (Table 3). In non-curricular areas, participation in one area led to a significant within semester increase in students' knowledge of the tenets of sustainability, but participation in none of the areas led to a significant increase in students' perceptions of the relevance of sustainability to their careers (Table 2).

*Assessment Goals:*In comparing the results with our goal, students in two courses knew enough of the tenets of sustainability, students in two courses sufficiently saw the relevance of sustainability to the course, and students in three courses sufficiently saw the relevance of sustainability to their careers (Table 3). In non-curricular areas, student participation in activities did not help them to reach the goal of knowing the tenets of sustainability, but participants in one area sufficiently saw the relevance of sustainability to their career (Table 2).

Table 1. Differences between (T) Treatment courses (those with sustainability embedded as a concept) and (C) Control courses (those without sustainability embedded as a concept) on students' knowledge of sustainability and their view of its importance to the course and their career at SUNY Delhi, Delhi, NY USA. Comparisons in bold are significantly different at α = 0.05. Numbers in parentheses are standard errors.

Course Name	Mean Change in # Known Tenets of Sustainability (Post minus Pre)	Mean Change in Students' View of the Relevance of Sustainability to the Course (Post minus Pre)	Mean Change in Students' View of the Relevance of Sustainability to Their Career (Post minus Pre)
ARCH 135 Architectural Design Fundamentals	**T 0.524 (0.16)**	T 0.04 (0.31)	T 0.38 (0.26)
	C -0.11 (0.20)	C 0.11 (0.20)	C 0.33 (0.24)
	P = 0.024	P = 0.850	P = 0.907
BIOL 110 Environmental Issues and Sustainability	**T 2.04 (0.20)**	**T -0.64 (1.00)**	T -0.04 (0.26)
	C -0.13 (0.09)	**C 0.31 (1.04)**	C 0.11 (0.25)
	P < 0.0001	**P = 0.001**	P = 0.685
BUSI 100 Introduction to Business	**T 0.65 (0.29)**	T 0.04 (1.15)	T 0.13 (0.26)
	C -0.32 (0.15)	C 0.37 (0.76)	C -0.40 (0.26)
	P = 0.005	P = 0.279	P = 0.156
HUMN 242 History of World and Western Architecture II	**T 1.78 (0.39)**	T -0.65 (0.22)	T -0.35 (0.15)
	C -1.14 (0.39)	C -0.17 (0.42)	C 0.21 (0.26)
	P < 0.0001	P = 0.325	P = 0.075

Discussion

The results from the courses show a similar trend in learning using the pre-post with control or the pre-post without control designs (Tables 1 and 3). The courses were most effective at helping students learn the tenets of sustainability. The pre-post without control revealed more significant effects of the courses than did the pre-post with control, however. Comparing the students' scores to a goal revealed the most successful findings including three out of four courses with students highly viewing the relevance of sustainability to their careers, which did not show up as significant in the other two study designs (Tables 1 and 3). The results from the non-curricular areas were more sporadic among study designs, highlighting the lower efficacy of the non-curricular areas relative to the courses (Table 2). In fact, there was no alignment of significant findings within areas across study designs. For example, the Resnick Learning Center helped students learn the tenets of sustainability based on the pre-post without control design but not in any other design (Table 2). Also, the O'Connor Center for Community Engagement helped students reach the goal of viewing sustainability as relevant to their careers, but there was not a significant change in that area when compared to control students (Table 2).

Table 2. Effect of non-curricular activities related to sustainability at SUNY Delhi, Delhi, NY USA on students' knowledge of the tenets of sustainability and their view of the importance of sustainability to their careers."T" refers to students who experienced the activities and "C" refers to students who did not. Data in bold indicate that the result met the goal or the comparison was significantly different at α = 0.05. Numbers in parentheses are standard errors.

Activity	Mean # Known Tenets of Sustain-ability (Post-Semester) **Goal of 2+**	Mean Relevance of Sustain-ability to Career (1 = High, 5 = Low; Post-Semester) **Goal of ≤ 2**	Mean # Known Tenets of Sustain-ability (Pre-Semester vs. Post-Semester)	Mean Relevance of Sustainability to Career (1 = High, 5 = Low; Pre-Semester vs. Post-Semester)	Mean Change in # Tenets Known (Post minus Pre for Treatment and Control groups)	Mean Change in Students' View of the Relevance of Sustainability to Their Career (Post minus Pre for Treatment and Control groups)
Resnick Learning Center	0.24 (0.07)	2.18 (0.18)	**Pre 0.60 (0.15)** **Post 0.24 (0.07)** **P = 0.035**	Pre 1.91 (0.16) Post 2.18 (0.18) P = 0.280	T -0.37 (0.14) C -0.38 (0.17) P = 0.961	T 0.18 (0.18) C 0.39 (0.13) P = 0.347
O'Connor Center for Community Engagement	0.42 (0.15)	**1.83 (0.37)**	Pre 0.33 (0.19) Post 0.42 (0.15) P = 0.732	Pre 1.82 (0.30) Post 1.83 (0.37) P = 0.975	**T 0.08 (0.15)** **C -0.47 (0.13)** **P = 0.008**	T 0.09 (0.21) C 0.33 (0.13) P = 0.351
Residence	0.30 (0.08)	2.03 (0.16)	Pre 0.42	Pre 1.83 (0.16)	**T -0.13 (0.11)**	T 0.10 (0.14)

Life		(0.11) Post 0.30 (0.08) P = 0.407	Post 2.03 (0.16) P = 0.479	**C -0.60 (0.18)** **P = 0.029**	C 0.47 (0.17) P =0.090

Without a control, it cannot always be determined if changes in students' knowledge and understanding came about because of the academic experience or because of something else that happened during the semester. For example, there was a significant increase in students' view of the relevance of sustainability to the History of Architecture course (Table 3), but that change was not significantly different from the change observed in the control class (Table 1). The control, in this case, provided greater analysis capacity than would a pre-post without control study design. Without having a pre-post comparison, it is not always clear whether the experience of the course or non-curricular activity actually brought about the change in student knowledge or appreciation. For example, students in three of the four courses reached the goal of viewing sustainability as important to their careers, but in none of the courses was there a significant increase in that perspective during the semester (Tables 1 and 3). Therefore, simply comparing students' knowledge and appreciation to a goal will not reveal the influence of the academic experience on those students.

Table 3.Effect of embedding sustainability into four courses at SUNY Delhi, Delhi, NY USA on students' knowledge of the tenets of sustainability and their view of the importance of sustainability to the course and their career. Data in bold indicate that the score met a goal or there is a significant difference in the comparison at α = 0.05. Numbers in parentheses are standard errors.

Course Name	Mean # Known Tenets of Sustain-ability (Post-Semester) Goal of 2+	Mean Relevance of Sustain-ability to Course (1 = High, 5 = Low; Post-Semester) Goal of ≤ 2	Mean Relevance of Sustain-ability to Career (1 = High, 5 = Low; Post-Semester) Goal of ≤ 2	Mean # Known Tenets of Sustainability (Pre-Semester vs. Post-Semester)	Mean Relevance of Sustainability to Course (1 = High, 5 = Low; Pre-Semester vs. Post-Semester)	Mean Relevance of Sustainability to Career (1 = High, 5 = Low; Pre-Semester vs. Post-Semester)
ARCH 135 Architectural Design Fundamentals	0.60 (0.15)	**2.00 (0.17)**	**1.92 (0.18)**	**Pre 0.11 (0.08)** **Post 0.60 (0.15)** **P = 0.007**	Pre 2.29 (0.14) Post 2.00 (0.17) P = 0.199	Pre 1.79 (0.14) Post 1.92 (0.18) P = 0.568
BIOL 110 Environmental Issues and Sustainability	**2.28 (0.20)**	**1.32 (0.17)**	**1.96 (0.19)**	**Pre 0.24 (0.09)** **Post 2.28 (0.20)** **P < 0.0001**	**Pre 1.96 (0.22)** **Post 1.32 (0.17)** **P = 0.004**	Pre 2.00 (0.16) Post 1.96 (0.19) P = 0.880
BUSI 100 Introduction to Business	1.17 (0.26)	2.22 (0.23)	2.30 (0.23)	**Pre 0.52 (0.15)** **Post 1.17 (0.26)**	Pre 2.17 (0.16) Post 2.22 (0.23) P = 0.857	Pre 2.17 (0.20) Post 2.30 (0.23) P = 0.623

				P = 0.032		
HUMN 242 History of World and Western Architecture II	**2.19 (0.24)**	2.27 (0.12)	**1.77 (0.13)**	**Pre 0.42 (0.11) Post 2.19 (0.24) P < 0.0001**	**Pre 2.92 (0.19) Post 2.27 (0.12) P = 0.006**	Pre 2.18 (0.15) Post 1.77 (0.13) P = 0.119

Ultimately, we want students to reach a sufficient level of understanding, appreciation, and capacity to learn (Fink, 2003; MSCHE, 2006; NEASC, 2012). Therefore, comparing students' scores to a goal is a wise study design to employ. But if we want to know the effect of our courses and non-curricular activities on helping students reach those goals, it is imperative to include at least a pre-post without control design and to include a control when possible.

Conclusion

To the best of our knowledge, this is the first direct comparison of experimental designs for assessment and the scholarship of teaching and learning. We hope that these results will be useful to those people who are designing assessment or education research projects. These results have demonstrated the importance of including pre- and post-semester data and using a control when conducting assessment or research on teaching and learning. However, the classroom is not a laboratory where every factor can be controlled. For example, control classes may not be available, a pre-test may bias a student's approach to a course, or there may be insufficient time for all data collection. We encourage education scholars to employ the best designs possible given the constraints of their situation, and to employ pre-post with control to go along with pre-set goals whenever possible.

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