Learning Statistics at the Farmers Market? A Comparison of Academic Service Learning and Case Studies in an Introductory Statistics Course

Bridget Hiedemann
Stacey M. Jones
Seattle University

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Abstract

We compare the effectiveness of academic service learning to that of case studies in an undergraduate introductory business statistics course. Students in six sections of the course were assigned either an academic service learning project (ASL) or business case studies (CS). We examine two learning outcomes: students' performance on the final exam and their perceptions of the relevance of statistics for their professional development. We find no statistically significant difference between ASL and CS students with regard to final examination performance, but students who participated in the ASL project as opposed to CS were less likely to agree that "[they] will have no application for statistics in [their] profession[s]." The estimated relationship is both large and statistically significant ($p < 0.01$).

1. Introduction

To demonstrate the relevance of statistics, introductory statistics courses frequently include projects in which students use statistics to analyze a real-world issue. In business schools, for example, case studies (CS) are often used to illustrate the use of statistical analysis in a business context. As an alternative to case studies, instructors are increasingly including academic service learning projects in their courses to engage students in a real-world project. Phelps and Dostilio (2008) usefully summarize the trend toward the incorporation of active learning and real world experiences within the teaching of statistics. Hydorn (2007) presents a variety of models for

incorporating academic service learning (ASL) in statistics courses. In an ASL project, students apply newly acquired knowledge and skills to address an issue currently facing the community, often working in partnership with a local non-profit or government agency. As noted by Anderson and Sungur (1999), service learning is especially well-suited to statistics courses because so many community organizations have data in need of summary and analysis. ASL projects have the potential to increase students' appreciation of the usefulness of course material by engaging students in a real-world project whose benefits extend beyond the classroom to the community at large.

As the phrase "academic service learning" suggests, instructors assign ASL projects both to enhance student learning and to provide a valued service to the broader community. The existing literature on the use of ASL in undergraduate statistics courses generally finds that participation in ASL projects has a positive impact on student learning outcomes. Based on their experiences with an optional service-learning project in an introductory statistics course, Root and Thorme (2001) conclude that a service-learning pedagogy increases students' engagement, their willingness to explore nuances, and their understanding of the material. Evangelopoulos, Sidorova, and Riolli (2003) investigate the relationship between participation in ASL projects and students' perceptions of the usefulness of the course material, their attitudes toward the course, and their intentions to use statistics in the future. Their results suggest that service learning enhances all three dimensions of students' attitudes toward statistics. Phelps and Dostilio (2008) find that students who choose service-learning projects experience greater enjoyment, social responsibility, and personal growth than those who choose traditional projects. Nordmoe (2007) reports that participation in a service-learning project increased most students' understanding of both the applicability and the usefulness of statistics. In a paper describing their experiences incorporating service-learning projects in an advanced undergraduate statistics course, Anderson and Sungur (1999) describe numerous benefits of this pedagogical approach; for example, service learning "stimulates inquiry-based learning" (p. 135) and highlights the relevance of the course material.

The goal of this study is to assess the relative effectiveness of ASL and CS in achieving two learning outcomes: 1) mastery of course content and 2) appreciation of the relevance of statistics to a student's own professional development. Our paper makes three main contributions to the literature on the effectiveness of ASL in undergraduate statistics courses. First, the paper directly compares the effectiveness of academic service learning (ASL) with that of case studies (CS), a widely-used method of bringing real-world examples into the business statistics classroom. By comparing the effectiveness of ASL to that of case studies, we are able to assess whether the community service dimension of ASL has pedagogical benefits above and beyond the case study.

Second, our methodology controls for several student characteristics in order to isolate the impact of ASL. In particular, our models control for students' mathematics competence at the onset of the course and demographic characteristics that might influence their performance in the course or their attitudes toward statistics. With the exception of the structural equation model presented in Evangelopoulos et al. (2003), our paper presents the only multivariate analysis in this literature.

Finally, our methodology limits the possibility of selection bias. While several studies have found ASL to have a positive impact on student learning, in nearly all of these studies, participation in the ASL project was optional, not required (Root and Thorme 2001; Phelps and Dostilio 2008; Evangelopoulos et al. 2003). These studies therefore risk self-selection bias: if only those students who found the subject matter of the ASL project compelling or only those students already more engaged in their studies chose to participate in ASL projects, it is not surprising that these students would ultimately express more favorable attitudes toward statistics.

Teaching several sections of a course in a single year provides a rich opportunity to compare the effectiveness of different pedagogies. The data used here to compare ASL to CS come from six sections of introductory business statistics taught across three academic quarters in 2008 by the authors. In four of the sections, students were required to participate in ASL projects; in the other two sections, students were required to participate in CS projects. When registering for courses, students had no information about the type of projects they would be assigned; hence there was no opportunity for self-selection into ASL or CS sections. One of the authors taught both ASL and CS sections in the same quarter; the data thus include results from students enrolled in sections that were near-identical in all respects other than the assignment of ASL or CS projects. Once enrolled, no students in the study elected to change from one section to another. The design of this study therefore permits us to compare ASL to CS quite cleanly as compared to most previous studies in which students self-selected into service learning projects.

In comparing the learning outcomes of ASL students to those of CS students, we find large and statistically significant differences between the two groups with regard to their perceptions of the relevance of statistics to their professional development. We do not, however, find a statistically significant difference between ASL and CS students with regard to mastery of the course content. In particular, students who participated in the ASL project displayed significantly lower odds than their CS counterparts of agreeing that "[they] will have no application for statistics in [their] profession[s]."

2. Course Projects

Case studies (CS) and academic service learning projects (ASL) require students to apply statistical concepts and techniques to the analysis of real or hypothetical questions that they might encounter in the business world. Our CS assignments ask the students to imagine themselves as business professionals or statistical consultants charged with the task of using available data or statistics to make a recommendation or provide information to a client or an organization. One assignment requires students to act as statisticians hired to consult executives of Wal-Mart Stores, Inc. concerning allegations of gender discrimination (Konrad and Mark 2004a, b). With descriptive statistics on earnings, performance reviews, and job titles, students address questions such as: Does the evidence suggest that the company has systematically discriminated against women? What additional information might be requested by a judge or a member of the jury in the class-action gender discrimination suit? Without access to the raw data, students need to think critically about the statistics provided and what other statistics might inform the various parties. Another assignment asks students to act as a financial advisor for a client deciding whether to invest in one of two individual stocks or a portfolio consisting of the two (Bryant and Smith 1998). The case provides 50 years of historical returns for the two

stocks. Successful analysis of the case requires students to determine which methods are appropriate for analyzing a portfolio of stocks and to apply these methods using Microsoft Excel. As these two examples illustrate, the CS assigned in this course emphasize real-world applications, interpretation, critical thinking, and communication to a non-technical audience.

The academic service learning project involves working with the Neighborhood Farmers Market Alliance (NFMA) on a price comparison study. The NFMA is a non-profit organization whose mission is to support Washington's small farms and farming families by providing effective direct sales sites for the region's small farmers and by educating consumers about local farm products and the benefits of buying directly from local farmers. ASL students work in partnership with the NFMA to conduct a study comparing prices of organic produce at local farmers markets to the prices of comparable produce at local grocery stores and food co-operatives. The NFMA aims to attract more shoppers by providing evidence that farmers markets provide competitive prices as well as high-quality produce. At the beginning of the quarter, a representative of the NFMA visits the ASL classes to introduce the organization and to familiarize students with the issues of local food production and farmland preservation. Following this visit, the class collects data on prices at the farmers market, grocery stores, and food co-operatives over a two-week period. Students work in groups, with each group responsible for gathering data at one location. Students then conduct hypothesis tests to determine whether the prices at the farmers market differ from those in the stores and co-ops.

ASL students are given the option of reporting their results in one of three forms: a research report to the NFMA, an article suitable for publication in the NFMA newsletter, or a combination of a poster and a brochure for the class display at the farmers market. After completing their projects, students return to the farmers market where they present their results to the community. Media interest in the project has also at times provided opportunities for the students to present their results to newspaper reporters and in radio interviews. The ASL project thus includes working with the community partner to design the project, data collection, analysis of the data based on concepts learned in the course, and verbal and written presentations of the results to a non-technical audience.

3. Theoretical Framework

The experiences documented in this paper provide an opportunity to contrast the impact of academic service learning (ASL) with that of case studies (CS). Both pedagogical methods are arguably built on the theoretical foundation of experiential learning (Kolb 1984; Kreber 2001; Silberman 2007). The experiential learning cycle involves four phases: concrete experience, active experimentation, abstract conceptualization, and reflection. Learning comes about through the integration of abstract conceptualization and concrete experience, coupled with reflection on the experience.

Kreber (2001) argues convincingly that the case study represents an effective form of experiential learning. An effectively taught case study engages students in a "particular real life situation as it happened in the past or as it could happen in the professional life of the student" (Kreber 2001, p. 222). Case studies have the potential to allow students to apply new skills and knowledge in an area of business or policy unfamiliar to them, going beyond course content to

engage a specific, real-world issue. This concrete experience forms the basis for active experimentation and the application of the concepts and theories being learned. The learning experience is bound together through reflection, for example, when the case study forms the basis of in-class discussions or student writing. Because the experience is generally confined to the classroom, case studies allow students to experiment with new skills and take risks in ways they might not in a professional setting.

Academic service learning shares with case studies a pedagogical foundation of experiential learning. The student's experience in the community, like a well-designed case study, provides a concrete, experiential base for skill application. However, there are several important differences between ASL and CS. First, in ASL, the concrete experience that provides the background and motivation for the subsequent statistical analysis is real and present; in CS, the background and motivation are often hypothetical or historical (although some instructors may involve their students in real and ongoing business case studies). The ASL experience may therefore be more vivid and engaging for the student. The real-life application of concepts may make students more receptive to the methodological content of the course (Anderson and Sungur 1999).

Second, ASL students generally enter into a professional relationship with a community organization, often a non-profit or government agency, in carrying out their projects, while CS students remain in a student-teacher relationship with their instructors. ASL students often interact directly with the organization and community members that benefit from their efforts. ASL students may feel a degree of professional accountability to the organizations or individuals with whom they work. If the project is not completed on time, or is not coherent or understandable, the organization and individuals involved are "noticeably and tangibly affected" (Godfrey 1999, p. 372). ASL students may therefore be more motivated to perform timely or quality work because the stakes are higher.

Finally, ASL projects produce both student learning and a valuable service for the community. Students with little intrinsic interest in statistics *per se* may nonetheless be motivated to learn statistics because it enables them to provide a valued service to others. Feldman, Moss, Chin, Marie, Rai, and Graham (2006) and Keith (2005) emphasize the reciprocity between the university and the broader community that underlies ASL. The design of the project, for example, is motivated not only by the organization the class works with but also by the pedagogical needs of the professor. The farmers-market project described here, for example, was designed jointly by the professor and a local farmers market organization. Students may come to see statistics as more useful because they see that their work serves the broader community.

Do these additional attributes of ASL relative to CS—increased concreteness, professional accountability, and service to the community—influence learning outcomes? Explicit course objectives tend to focus on the mastery of course content. The syllabi for the statistics course described in the paper list objectives such as developing "a robust understanding of the fundamental concepts of statistics" and "the ability to communicate the results of statistical analysis accurately and concisely."

Many colleges and universities, however, explicitly aim at achieving not only course content learning, but the personal and professional development of the student. There is an institutional hope that by some sort of synergy the overall college experience of students will be greater than the sum of its parts. For example, Seattle University's mission reads, "This university is dedicated to educating the whole person, to professional formation, and to empowering leaders for a just and humane world." The phrase "professional formation" presumably involves both the mastery of course content and the appreciation of the relevance of that content within one's chosen profession.

The aim of many universities to provide an educational experience that results not only in the mastery of skills and knowledge but also in professional formation highlights the importance of understanding whether ASL or CS is more effective in achieving this aim. For this reason, we evaluate two broadly framed propositions:

1. As compared to CS, ASL is more effective in promoting the mastery of course content learning—that is, learning related to course-level knowledge and problem solving skills. While both CS and ASL represent forms of experiential learning, ASL arguably involves a more concrete experience and greater professional accountability, as well as service to the wider community. Does the additional concreteness, accountability, or service to the community improve course content learning, as measured by final examination performance?

2. As compared to CS, ASL is more effective in enhancing students' appreciation of the relevance of statistics to their professional development. CS projects are typically carried out in class or submitted as a writing assignment for a professor. While students may be asked to play the role of an expert or statistical consultant, this experience is simulated, not real. ASL, however, puts students into a real setting where they are asked to use their newly acquired skills to perform a service that benefits the community at large. Does the experience of seeing statistics used to benefit the community enhance students' attitudes concerning the usefulness of statistics and its relevance to their professional development?

4. Data

We rely on several sources of data to examine the relative effectiveness of academic service learning (ASL) and case studies (CS) with regard to students' mastery of course content as well as their perceptions of the relevance of statistics for their professional development. In particular, we use responses to a background survey, scores on a mathematics competency exam, responses to Schau, Stevens, Dauphinee, and Del Vecchio's (1995) Survey of Attitudes Toward Statistics (SATS), and final exam scores.

We administered the background survey and the mathematics competence exam at the beginning of the quarter. The background survey includes questions concerning a student's demographic characteristics and academic background; the mathematics competency exam consists of 30 questions designed to assess students' proficiency with algebra and pre-calculus at the outset of the course. The two surveys are included as appendices.

The SATS assesses four dimensions of students' attitudes towards statistics: affect, cognitive

competence, value, and difficulty (Gal, Ginsburg, and Schau (1997). Confirmatory factor analysis based on a sample of undergraduate students provides validity for this structure (Schau et al. 1995; Gal et al. 1997). For the purposes of our analysis, we converted the seven-point Likert-type items from the SATS to five-point items to reduce the likelihood of small cell sizes. Thus, in our version of the SATS, possible responses range from "strongly agree" to "neither agree nor disagree" to "strongly disagree." We administered the SATS at the beginning and at the end of the quarter.

As discussed in more detail in Section 5.2, our analysis of students' attitudes concerning the relevance of statistics for their professional development focuses on responses to two items on the SATS. The first of these items is positively framed, namely "Statistics should be a required part of my professional training;" the second is negatively framed, namely "I will have no application of statistics in my profession."

We use responses to the "post" version of the SATS to examine the relative effectiveness of ASL and CS with regard to students' perceptions of the relevance of statistics for their professional development. We use responses to the "pre" version of the SATS to examine whether there were any systematic differences in initial attitudes between students enrolled in ASL sections and those enrolled in CS sections.

We collected background information, mathematics competency scores, and statistics attitudes for students enrolled in six sections of the course over three academic quarters in 2008. As illustrated in Table 1, four of these sections included an ASL project; the other two sections included CS assignments. Professor B taught all of the ASL sections and one of the CS sections. Professor A also has considerable experience teaching this course but taught only one of the six sections offered in 2008.

Table 1. Characteristics of the Six Sections

Quarter	Professor	Form of Experiential Learning	Enrollment
Winter	A	CS	35
Winter	B	ASL	39
Spring	B	CS	34
Spring	B	ASL	37
Fall	B	ASL	30
Fall	B	ASL	30

Most of the students enrolled in these six sections—201 out of 205 or approximately 98.0%—completed the course. After excluding 28 observations with missing responses to one or both of the SATS items used in our analysis and nine additional observations with missing mathematics competency scores, the resulting sample includes 164 students. About 63% of the sample (104 students) participated in an ASL project and about 82 percent of the sample (135 students) were enrolled in one of Professor B's sections.

The design of this study limits the possibility of selection bias— due to students selecting into ASL or CS sections or due to students choosing to leave or switch sections based on the type of project assigned. Since students had no information when registering for classes whether ASL or CS projects would be assigned, and since all students in a particular section were required to participate in the same type of project, students had no opportunity to self-select into ASL or CS sections. In addition, once students had learned about the type of projects they were assigned, no students chose to switch sections. With regard to attrition, withdrawal rates were low in all sections (two out of 136 or 1.5% of students enrolled in ASL sections and two out of 69 or 2.9% of students enrolled in CS sections did not complete the course). Therefore, although the assignment of students to sections was not randomized, no students were able to select into a given section on the basis of the type of project assigned, and only a very few, if any, selected out of a given section on the basis of the type of project.

As shown in Tables 2 and 3, the sampled students are diverse in terms of their mathematical competence at the onset of the course, gender, and native language. Scores on the mathematics competency exam range from 8 to 29 out of 30 possible points with a mean of about 22 points and a standard deviation of over 4 points. Almost half (approximately 48.2%) of the students are female and almost one fourth (approximately 22.6%) do not speak English as their native language.

Table 2. Means and Standard Deviations of Mathematics Competency Scores

Variable	Full Sample	CS	ASL	P-Value
Score on 30-Point Math Competency Exam	22.24 (4.44)	21.82 (4.34)	22.49 (4.50)	0.35

NOTES: Standard deviations are indicated in parentheses. The p-value corresponds to a test for the differences between two means assuming unequal variances.

Table 3. Percentages of Female Students and Native Speakers

Variable	Overall Sample	CS	ASL	P-Value
Female	48.2%	43.3%	51.0%	0.35
Native Speaker	77.4%	76.7%	77.9%	0.86

NOTES: The p-values correspond to Pearson's chi-square test.

Stratifying the sample by the form of experiential learning does not reveal systematic differences in mathematical competence, demographic characteristics, or initial attitudes towards statistics across the ASL and CS sections. As indicated in Table 2, there is not a statistically significant difference between the mathematics competency scores of ASL students as compared to CS students ($p = 0.35$). Moreover, as shown in Table 3, we cannot reject the null hypothesis that the form of experiential learning is independent of gender ($p = 0.35$) or the null hypothesis that it is

independent of native language (p = 0.86). Similarly, we cannot reject the null hypothesis that the form of experiential learning is independent of a student's response to the positively-framed Likert item at the onset of the course (p = 0.17), nor can we reject the null hypothesis that the form of experiential learning is independent of a student's response to the negatively-framed Likert item at the onset of the course (p = 0.86).

Likewise, the ASL and CS sections are similar with regard to the distribution of college majors. Although it is not uncommon for business students at Seattle University to take the introductory statistics course before declaring a major, 139 of the 164 students in our sample—or 84.8%— reported at least one major area of study. Among those who reported a major, 40.7% of ASL students and 42.0% of CS students indicated at least one major in a relatively quantitative business field, namely accounting, finance, or economics. At Seattle University, the Department of Economics is in the business school; accordingly, we list economics as a business major even though it is more commonly classified as a social science. Approximately half of the students who reported a major (50.0% of the ASL and 49.1% of the CS students) indicated more qualitative business fields such as management, marketing, or international business. The remaining 9.3% of ASL and 9.4% of CS students who reported majors listed a wide range of fields outside of business such as English, criminal justice, biology, computer science, environmental studies, and applied math.

As discussed above, the sampled students exhibit considerable variation in terms of their mathematics competence at the onset of the course; similarly, they display considerable variation with regard to their final exam scores. Among the subsample of 60 students from the two sections with an identical final exam (31 students in the CS section and 29 students in the ASL section), scores vary from 35% to 100% with a mean of about 78% and a standard deviation of almost 13%. As shown in Table 4, the mean score in the ASL section is higher than that in the CS section but the difference is neither large nor statistically significant.

Table 4. Means and Standard Deviations of Final Exam Scores

Variable	Full Sample	CS	ASL	P-Value
Percent Scored on Final Exam	78.26 (12.98)	77.02 (14.39)	79.60 (11.38)	0.44

NOTES: Standard deviations are indicated in parentheses. The p-value corresponds to a test for the difference between two means assuming unequal variances.

As shown in Table 5, students' attitudes concerning the value of statistics upon completion of the course also display considerable variation. However, most attitudes are favorable. For example, 91 of the 164 sampled students—about 55.5%—agreed or strongly agreed that "statistics should be a required part of [their] professional training." Similarly, 123 of the 164 sampled students— or 75%—disagreed or strongly disagreed that "[they] will have no application of statistics in [their] profession[s]."

Table 5. Frequency Distributions for Students' Attitudes Towards Statistics: Totals and Percentages (in Parentheses)

		Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
"Statistics should be a required part of my professional training."	Overall Sample	39 (23.8%)	52 (31.7%)	51 (31.1%)	16 (9.8%)	6 (3.7%)
	ASL Students	26 (25.0%)	35 (33.7%)	30 (28.8%)	11 (10.6%)	2 (1.9%)
	CS Students	13 (21.7%)	17 (28.3%)	21 (35.0%)	5 (8.3%)	4 (6.7%)
"I will have no application of statistics in my profession."	Overall Sample	2 (1.2%)	6 (3.7%)	33 (20.1%)	70 (42.7%)	53 (32.3%)
	ASL Students	0 (0.0%)	3 (2.9%)	18 (17.3%)	47 (45.2%)	36 (34.6%)
	CS Students	2 (3.3%)	3 (5.0%)	15 (25.0%)	23 (38.3%)	17 (28.3%)

5. Methods and Findings

5.1 Mastery of Course Content

Our first proposition states that academic service learning (ASL) is more effective than case studies (CS) in promoting course content learning. Were this the case, we would expect students who participated in the ASL project to outperform their peers on the final exam, after controlling for relevant characteristics. Accordingly, we estimate ordinary least squares (OLS) regression models where the dependent variable represents the percentage of possible points received by the student on the final exam. We restrict this analysis to the 60 students enrolled in the two sections offered during the spring quarter, 31 students in the CS section and 29 students in the ASL section. With the exception of the form of experiential learning, these two sections were as similar as possible. Most notably, Professor B taught both sections and administered identical final examinations.

The key independent variable is a dummy variable distinguishing between the two forms of experiential learning (ASL = 1 in the section with an ASL project, ASL = 0 in the section with CS). Given the diverse mathematical backgrounds of our students, we control for the student's initial score on the mathematics competency exam. While a parsimonious specification includes only the form of experiential learning and the student's mathematical competence, a more

complete specification also controls for two demographic characteristics, gender and native language (whether the student's native language is English).

Although, as shown in Table 6, the coefficient associated with the dummy variable for ASL is positive in both specifications, the relationship is not statistically significant at conventional levels in either the sparse ($p = 0.853$) or the more complete ($p = 0.829$) specification. As one might expect, performance on the final exam is positively associated with a student's mathematical competence at the onset of the course, a relationship that is highly statistically significant ($p < 0.0001$) in both specifications.

Table 6. OLS Models of Performance on the Final Exam

	Model 1	Model 2
Variable	Parameter Estimates (standard errors in parentheses)	
Intercept	46.969** (7.383)	49.330** (7.955)
ASL	0.559 (2.999)	0.652 (3.008)
Mathematics Competence	1.453** (0.343)	1.465** (0.344)
Female		1.064 (3.016)
Native Speaker		-4.166 (3.450)
R Squared	0.247	0.270
R Squared Adjusted	0.221	0.217
Sample Size	60	60
*$p < 0.05$, **$p < 0.01$		

5.2 Perceptions of the Relevance of Statistics

Our second proposition states that ASL is more effective than CS in promoting students' attitudes and beliefs concerning the value of statistics for their professional development. The SATS includes nine items "measuring attitudes about the usefulness, relevance, and worth of statistics in personal and professional life" (Gal et al. 1997). Given our interest in students' attitudes and beliefs concerning the value of statistics for their professional development, our analysis relies on responses to the two SATS items that pertain to the value of statistics for a student's own professional development (as opposed to his or her employability, the value of statistics for the typical professional, or the value of statistics in personal life). The first of these items is positively framed while the second is negatively framed:

"Statistics should be a required part of my professional training."

"I will have no application of statistics in my profession."

In the case of ordinal dependent variables such as Likert items, OLS models generate biased estimates (Long 1997). We therefore estimate ordered logit models to test whether students' attitudes and beliefs concerning the value of statistics for their professional development are more favorable among students who participated in an ASL project than their peers in sections with CS, after controlling for the instructor and characteristics of the student. For this analysis, we use the full sample of 164 students. Since only two students strongly agreed that "[they] will have no application of statistics in [their] profession[s]" (see Table 5), we combined these two students with those who agreed with this statement. Moreover, for consistency across models and ease of interpretation, we collapsed the "strongly agree" and "agree" responses as well as the "strongly disagree" and "disagree" responses for both dependent variables.

For each of these two dependent variables, we present estimates associated with two models where the key independent variable is a dummy variable distinguishing between ASL and CS. Despite efforts to make our sections as similar as possible with regard to course content and assignments, no two instructors are identical; thus, both specifications also include a dummy variable distinguishing between the two instructors (PROFA=1 for Professor A, PROFA=0 for Professor B). In addition, our more complete specification controls for three student characteristics: mathematical competence, gender, and native language. Table 7 displays the parameter estimates and the estimated odds ratios associated with each ordered logit model.

Table 7. Ordered Logit Models

Dependent Variable	"Statistics should be a required part of my professional training"				"I will have no application for statistics in my profession."			
	Parameter Estimates (standard errors)	Odds Ratios	Parameter Estimates (standard errors)	Odds Ratios	Parameter Estimates (standard errors)	Odds Ratios	Parameter Estimates (standard errors)	Odds Ratios
Variable								
Agree Threshold	0.389 (0.342)		1.463 (0.871)		2.096** (0.450)		0.816 (1.007)	
Neutral Threshold	-1.290** (0.363)		- 0.289 (0.863)		0.153 (0.353)		- 1.170 (0.985)	
ASL	0.724 (0.388)	2.063	0.643 (0.397)	1.902	-1.229** (0.427)	0.293	-1.145** (0.436)	0.318
PROFA	0.879 (0.503)	2.408	0.771 (0.517)	2.162	-1.193* (0.576)	0.303	-1.104 (0.591)	0.332
Mathematics Competence			0.079* (0.035)	1.082			-0.073 (0.040)	0.930
Female			-0.042 (0.312)	0.959			-0.173 (0.374)	0.841
Native Speaker			-0.748 (0.399)	0.473			0.381 (0.471)	1.464
Log-likelihood	-155.260		-150.653		-108.302		-106.108	
Sample Size	164		164		164		164	
*p < 0.05, **p < 0.01								

NOTES: As discussed in the text, for each Likert item, we collapsed the "strongly agree" and "agree" responses into a single affirmative response; similarly, we collapsed the "strongly disagree" and "disagree" responses. Since parameter estimates represent log odds ratios, the estimated odds ratios are obtained by exponentiating the corresponding parameter estimate. For example, the estimated odds ratio associated with ASL for the first model is exp(0.724) or 2.063.

Given our focus on the relative effectiveness of ASL and CS in promoting students' attitudes and beliefs concerning the value of statistics for their professional development, Table 8 presents 95% confidence interval estimates for the odds ratios associated with the form of experiential learning.

Table 8. 95% Confidence Interval Estimates for Odds Ratios: ASL vs. CS

Dependent Variable	Model	Lower Limit	Upper Limit
"Statistics should be a required part of my professional training."	Sparse	0.969	4.392
	More Complete	0.882	4.098
"I will have no application of statistics in my profession."	Sparse	0.126	0.684
	More Complete	0.134	0.758

NOTES: Confidence intervals for the odds ratios are obtained by exponentiating the lower and upper limits of the confidence intervals associated with the parameter estimates; given the asymmetry of the odds ratio scale, the estimated odds ratios are not the midpoint of the corresponding confidence intervals (Bland and Altman 2000).

As shown in Table 7, in both the sparse (p = 0.004) and the more complete (p = 0.009) specification, participating in the ASL project rather than CS statistically significantly reduces the odds that a student agrees that "[he or she] will have no application for statistics in [his or her] profession." The estimated odds ratios are both less than one third, namely 0.293 and 0.303. As shown in Table 8, the corresponding 95% confidence intervals range from 0.126 to 0.684 for the sparse specification and from 0.134 and to 0.757 for the more complete specification. In this case, the reciprocals of the estimated odds ratios have a more intuitive interpretation: relative to ASL students, CS students display more than three times the odds—3.413 and 3.300—of agreeing that "[they will have no application of statistics in [their] profession[s]," with corresponding 95% confidence intervals ranging from 1.462 to 7.937 and 1.321 to 7.463.

The relationship between the form of experiential learning and responses to the positively-framed Likert item ("Statistics should be a required part of my professional training.") also has the expected sign. However, the coefficients on the ASL dummy variable are not statistically significant at conventional levels (p = 0.062 in the sparse specification; p = 0.105 in the complete specification).

The other course-level characteristic included in the model, the instructor, may influence students' perceptions of the relevance of statistics for their professional development. Recall that Professor B taught five sections of the course during the time frame in question, while Professor A taught one section. Professor B used ASL in four sections and CS in one section, while Professor A's only section included CS. Thus, our model enables us to distinguish differences

between the two instructors from differences between the two forms of experiential learning. It is worth noting that estimates of the models using only the subsample of students in Professor B's sections result in parameter estimates similar in magnitude and statistical significance to those reported here.

6. Discussion and Conclusion

The study finds support for one of our two propositions regarding the effectiveness of academic service learning (ASL) relative to case studies (CS). With respect to the mastery of course content, the estimated effect of ASL relative to CS is positive but not statistically significant. Thus, our results do not provide evidence in favor of our first proposition, that ASL enhances course content learning relative to CS. In interpreting this finding, it should be noted that for students in this study, participating in ASL relative to CS required additional time both in and out of class. A guest speaker attended one of the ASL but not one of the CS course meetings. Students in the ASL sections gathered original data and presented their results at the farmers market, both of which required substantial out-of-class time. With these additional requirements, perhaps we might be encouraged that participation in an ASL project did not reduce these students' course performance as measured by a conventional final examination.

Although we do not find statistically significant differences in final examination performance, focus group discussions with ASL participants suggest that participation in the ASL project may have enhanced their course content learning. After completing the course, 18 students from two of the service-learning sections volunteered to participate in focus group discussions in order to evaluate the ASL project and offer suggestions for future sections. In two focus groups with these 18 students, the facilitator, a professor from outside the department, asked the students a series of questions concerning their experiences with the ASL project, most notably: "Were there some things you learned from the community-research project that you would not have learned if the course had been taught in a more traditional fashion (without the community research)?" One participant commented that he/she was more motivated to "really understand the math behind the concepts because [he/she] wanted to know how the concepts worked in real life." Another participant claimed that participation in the ASL project "helped [him/her] learn to collect data, determine which data were relevant or irrelevant, communicate the data in layman's terms." Perhaps participation in the ASL project enhanced dimensions of course content learning not captured by the final examination, which focused on demonstrating mastery of statistical concepts such as hypothesis testing but did not evaluate data-collection or communication skills. However, the focus group discussions must be interpreted with caution in part because participation was voluntary. Moreover, focus groups with students from sections with case studies—had they been conducted— may have revealed similar benefits.

As indicated by our second proposition, we expected ASL to be more effective than CS in promoting students' appreciation of the relevance of statistics for their professional development. Not only is ASL more vivid and engaging than CS, but ASL puts the students in a position of professional responsibility, in which they are accountable for their work to a non-profit organization and to the community at large. ASL participants step into a genuinely professional role for a time, whereas CS students only take on that role as a writing exercise.

Student survey responses at the end of the course support the proposition that ASL students are more likely than CS students to view statistics as relevant to their profession. The ordered logit models of the survey responses indicate that ASL students are statistically significantly more likely to disagree that they "will have no application of statistics in [their] profession[s]" ($p < 0.01$). Moreover, the estimated odds ratios and corresponding 95% confidence intervals suggest that the magnitude of this relationship is substantively significant. Student responses to the positively-framed Likert item ("Statistics should be a required part of my professional training") also suggest that ASL has a positive impact on student attitudes regarding statistics. The relationship, however, is not statistically significant at conventional levels ($p = 0.062$ in the sparse specification; $p = 0.105$ in the complete specification).

While the focus groups were not representative of the class as a whole, students' focus group responses can help us understand how participation in an ASL project influences attitudes toward statistics. Students in one focus group mentioned that working in partnership with the NFMA was an important motivator for them to do high quality work: to "make it more professional" or to "do better in all aspects of the project." One focus group participant commented that the ASL project increased his appreciation for statistics because he collected relevant data and applied it to help members of the community. Another participant stated that she would recommend taking the course with the ASL project, in part because it provided her with a much better understanding of how statistics can be used to make a positive impact in the real world.

Moore (2000) calls for greater integration of research on service learning and on experiential education in order to answer a number of important questions: What pedagogical strategies best foster learning? How does ASL as compared to other pedagogies within and outside of experiential learning more generally build skills and help students develop in their chosen profession? Does ASL have any advantages over other forms of experiential learning in contributing to personal development and the capacity for civic engagement (Moore 2000, p. 124)? This study helps to more clearly delineate the boundary between CS, arguably a form of experiential learning, and ASL, a form of experiential learning with the additional component of community service and accountability to external stakeholders.

This study has obvious relevance for business schools, where the case study method is prevalent. However, the results generalize beyond the business school to other disciplines. In engineering and the natural sciences, for example, experiential learning is widespread, in the form of hands-on projects and laboratory experiments. This study suggests that academic service learning, above and beyond experiential learning, may enhance students' perceptions of the professional relevance of the course material.

Appendix A: Background Survey

1. Gender: _____

2. Age: _____

3. Which of the following Census categories best describes you: (1) White, (2) Black or African American, (3) American Indian or Alaska Native, (4) Asian, (5) Native Hawaiian or Other Pacific Islander, or (6) Some Other Race. You may list more than one.   _____

4. Nationality: _____

5. Do you consider English your native language?   _____

6. College major: _____

7. Number of quarters of college completed: _____

8. Number of years of high school mathematics taken (1-4):   _____

9. How well did you do in your high school mathematics courses? Rate your performance from 1 to 5, where 1 means "very poorly" and 5 means "very well."   1 2 3 4 5

10. Number of college mathematics and/or statistics courses taken (other than this one):   _____

11. How well did you do in your college mathematics/statistics courses? Rate your performance from 1 to 5, where 1 means "very poorly" and 5 means "very well."   1 2 3 4 5

12. Computer background: rate yourself from 1 to 5, where 1 means little/none, 3 means some, and 5 means extensive: 1 2 3 4 5

13. How good at mathematics are you? Rate yourself from 1 to 5, where 1 means not good at all, 3 means OK, and 5 means very good.   1 2 3 4 5

14. How much experience with statistics did you have before taking this course? Rate yourself from 1 to 5, where 1 means "none" and 5 means "a great deal."   1 2 3 4 5

15. In the field in which you hope to be employed when you finish college, how much will you use statistics? Let 1 mean "not at all," 3 mean "sometimes," and 5 mean "a great deal."   1 2 3 4 5

Appendix B: Mathematics Competency Exam

Instructions: Please answer the following without the use of a calculator. Write your answer in the blank at the right. You may give your answer as a fraction, decimal, whole number, or symbolic expression (such as "2a").

1. $5/6$ x $18/25$ =   1._____

2. $3/7 + 2/3$ =   2._____

3. $11/25$ =   %   3._____

4. $-5.2 - (-11.3)$ =   4._____

5. $(5 \times 6) + 4$ =   5._____

6. $-3/7 - (-1/4)$ =   6._____

7. 12 is what percent of 40?   7._____

8. If $f(x) = x^2 - x + 2$, then $f(5)$ =   8._____

9. If $f(x) = x^2 - x + 2$, then $f(2a)$ =   9._____

10. $x + 5 = 12.7$. $x =$ 10._____

11. $5x + 9 = 3x + 1$. $x =$ 11._____

12. $5(3x - 2) = 35$. $x =$ 12._____

13. If $x^2 + 6x = -9$, then $x =$ 13._____

14. Solve the two equations simultaneously to find the values of x
     and y. Write the value of **x** on the line.   14._____

   $x + y = 2$
   $x + 2y = 5$

15. When x is plotted on the horizontal axis and y on the vertical
     axis, what is the slope of the line $y = 2x - 3$?   15._____

16. $\log (xy) = (\log x)(\log y)$ **or** $(\log x) + (\log y)$ 16._____

17. If x^2 is multiplied by x^3 the result is   17._____

18. $(x^{-2})^4$ =   18._____

19. $e^{(x+y)} = e^x e^y$ **or** $e^x + e^y$ 19._____

20. $e^{(x-y)} = e^x/e^y$ **or** $e^x - e^y$ 20._____

21. $\log (x/y) = (\log x) / (\log y)$ **or** $(\log x) - (\log y)$ 21._____

22. If $x_1 = 2, x_2 = 4, x_3 = 6, x_4 = 8$, then $\sum_{i=1}^{4} x_i =$ 22._____

23. If $x_1 = 2, x_2 = 4, x_3 = 6, x_4 = 8$, then $\sum_{i=2}^{3} x_i =$ 23._____

24. Which of the two is greater: 1/5 or 1/4?   24._____

25. Which of the two is greater: -1/5 or -1/4?   25._____

26. Convert the following to a decimal: -(4/5) =   26._____

Questions 27-30. In a survey of 1,000 randomly selected adults (500 males, 500 females) employment status was determined. The following results were obtained:

	Males	Females	Total
Employed full-time	350	300	650
Employed part-time	75	100	175
Not employed	75	100	175

27. What proportion of males were employed?   27._____

28. What proportion of adults were employed part-time?   28._____

29. What is the ratio of males to females who are employed part-time?   29._____

30._____

30. Of those females who are employed, what percent are employed part-time?

Acknowledgments

References

Anderson, J. E., and Sungur, E. A. (1999), "Community Service Statistics Projects," *The American Statistician*, *53*(2), 132-136.

Bland, J. M., and Altman, D.G. (2000), "Statistics Notes: The Odds Ratio," *British Medical Journal*, *320*(7247): 1468.

Bryant, P. G., and Smith, M. A. (1998), *Practical Data Analysis: Case Studies for Business Statistics* (2nd ed.), New York: McGraw Hill.

Evangelopoulos, N., Sidorova, A., and Riolli, L. (2003), "Can Service-Learning Help Students Appreciate an Unpopular Course? A Theoretical Framework," *Michigan Journal of Community Service Learning*, *9*(2), 15-24.

Feldman, A., Moss, T., Chin, D., Marie, M., Rai, C. & Graham, R. (2006), "The Impact of Partnership-Centered, Community-Based Learning on First-Year Students' Academic Research Papers," *Michigan Journal of Community Service Learning 13*(1), 16-29.

Gal, I., Ginsburg, L. & Schau, C. (1997), "Monitoring Attitudes and Beliefs in Statistics Education," In Gal, I. & Garfield, J.B. (eds.), *The Assessment Challenge in Statistics Education* (pp. 37-51), Amsterdam: IOS Press (on behalf of the ISI).

Garfield, J. (1996), "Assessing Student Learning in the Context of Evaluating a Chance Course," *Communications in Statistics. Theories and Methods*, *25*(11), 2863-2873.

Godfrey, P. (1999), "Service-Learning and Management Education: A Call to Action," *Journal of Management Inquiry*, *8*(4), 363-378.

Hydorn, D. L. (2007), "Community Service-Learning in Statistics: Course Design and Assessment," *Journal of Statistics Education*, 15(2).

Keith, N. Z. (2005), "Service Learning in the Face of Globalization: Rethinking Theory and Practice," *Michigan Journal of Community Service Learning 11*(2), 5-24.

Kolb, D. A. (1984), *Experiential Learning,* Englewood Cliffs, NJ: Prentice Hall.Konrad, A. & Mark, K. (2004a), *Staffing Wal-Mart Stores*, Richard Ivey School of Business, Publication 9B04C006.

Konrad, A. & Mark, K. (2004b), *Staffing Wal-Mart Stores*, Richard Ivey School Business, Publication 9B04C007.

Kreber, C. (2001), "Learning Experientially Through Case Studies? A Conceptual Analysis," *Teaching in Higher Education, 6*(2), 217-228.

Long, J. S. (1997), *Regression Models for Categorical and Limited Dependent Variables: Analysis and Interpretation* (5th ed.), London: Sage.

Moore, D. T. (2000), "The Relationship Between Experiential Learning Research and Service-Learning Research," *Michigan Journal of Community Service Learning, Special Issue no. 1*, 124-128.

Nordmoe, E. D. (2007), "Service-Learning in Introductory Statistics at Kalamazoo College," *Journal of Statistics Education*, 15(2).

Phelps, A. & Dostilio, L. (2008), "Studying Student Benefits of Assigning a Service-Learning Project Compared to a Traditional Final Project in a Business Statistics Class," *Journal of Statistics Education, 16(3),* 1-11.

Root, R. & Thorme, T. (2001), "Community-Based Projects in Applied Statistics: Using Service-Learning to Enhance Student Understanding," *The American Statistician*, 55, 326-331.

Schau, C., Stevens, J., Dauphinee, T. L. & Del Vecchio, A. (1995), "The Development and Validation of the Survey of Attitudes Toward Statistics," *Educational and Psychological Measurement, 55*(5): 868-875.

Silberman, M. L. (2007), "Introducing: The Handbook of Experiential Learning," In Silberman (ed.), *Handbook of Experiential Learning* (pp. 1-10), San Francisco: John Wiley and Sons.

Bridget Hiedemann
Department of Economics
Seattle University
901 12th Avenue
P.O. Box 222000
Seattle, WA 98122
Email: bgh@seattleu.edu
Phone: (206) 296-2803
Fax: (206) 296-2486

Stacey M. Jones
Department of Economics
Seattle University
901 12th Avenue
P.O. Box 222000
Seattle, WA 98122
Email: sjones@seattleu.edu
Phone: (206) 296-5790
Fax: (206) 296-2486