Is it Real and Is it Really working?

Measuring student learning and perspectives following curriculum changes

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Abstract

Summary results of the effects of several years of developing pedagogy designed to give students real data experiences in a two-semester Business Statistics sequence on student retention are reported. Traditionally students have demonstrated their capacity to perform a complete statistical analysis through the use of written reports summarizing the results of student generated projects. The advantage of a two-semester business statistics sequence with a retention assessment in an upper level core course provides the opportunity to do more. Pedagogy changes that include optional service-learning (SL) projects, required oral presentations and end-of-semester reflection papers track student retention. Instruction further supports real data applications through bi-weekly lab assignments, critiquing of media headlines and timed written assignments on project progress to promote communication of steps required in a research project. Student performance is measured by a retention exam given in an upper level core course following a gap of at least a one-semester summer break. Student perceptions of real data applications are measured by prompted reflection questions.

Students self-selecting a two-semester SL project have higher course grades ($p<0.01$) and write more freely about satisfaction and personal development. Course grades continue to be the strongest predictor of increased retention ($p<0.01$), while increased time between taking the statistics course and the retention exam reduce performance ($P<0.01$). Required oral presentations may positively increase retention ($p=0.06$) after controlling for students' grades in the second business statistics course. Additionally, students self-reported significantly higher levels of confidence ($P<0.001$) in performing statistical analyses following the second course of business statistics using a paired comparison.

Key Words: Retention, Real data, service-learning

1. Introduction

The Statistical reform movement of the 1990's expressed concern about students' grasp of statistical reasoning and their ability to interpret statistical conclusions in writing using understandable terminology. This reform movement focused primarily on the introductory or service courses in statistics (Cobb, 1992, 1993; Hoaglin & Moore 1992; Hogg 1991, 1992; Moore 1991; NCTM 1989, 1993). Many offered suggestions for improving classroom pedagogy by using real data, experiential learning, incorporating technology and increased writing assignments from which to gain authentic assessment (Archbald and Newmann 1988, Angelo and Cross, 1993, Crowley 1993, Garfield, 1994 & Chance 1997). Butler (1998) expressed increasing concern citing a lack of or improper applications of statistical concepts in the workplace. In 2001, following a large scale survey of statistics instructors, Garfield (2001) concluded that although there is evidence of widespread reform, there is no quality assessment instrument available to measure student's mastery of statistical reasoning and literacy. In response, the CAOS test was designed and implemented (delMas, Garfield, Ooms & Chance, 2007). The results from this testing were not all together encouraging. In general, students demonstrated increased difficulty with interpreting boxplots, understanding important design principles, and concepts related to probability, sampling variability and inferential statistics. Other studies have confirmed these findings indicating that students were falling short in their conceptual understanding of reasoning about *distributions and graphical representations* of distributions (Konold & Higgins, 2003; McClain, Cobb, & Gravemeijer, 2000), understanding concepts related to *statistical variation* such as measures of variability (Shaughnessy, 1977; delMas & Liu,2005), *sampling variation* (Reading & Shaughnessy, 2004), and *sampling distributions* (delMas, Garfield, & Chance, 1999 and 2004; Saldanha and Thompson, 2001). Wild and Pfannkuch (1999) argued that we really do not know how to teach students to think like statisticians and solve problems. An often used strategy is to assign projects and hope that something develops. This strategy along with a first attempt to create technology lab assignments to provide the basis for preparing students to design and complete their projects began when I accepted a teaching position in an AACSB accredited Business School in which undergraduate business majors were required to complete a two-semester business statistics sequence.

2. Methods

A two-semester undergraduate business statistics program provides the opportunity to reinforce statistical reasoning taught in a first course of introductory statistics. A brief description of the topics covered in the two semester is given below.

Business Statistics I:
- ✓ Descriptive statistics including least squares equation
- ✓ Probability Rules presented through applications of contingency table
- ✓ Normal distribution, CLT, Sampling distributions for means and proportions
- ✓ One sample inference
- ✓ Two sample inference introduced conceptually

Business Statistics II:
Emphasizes modeling through applications of cases
- ✓ One and two sample inference is revisited with applications focused on using independent variable(s) to model/predict dependent variable
- ✓ Paired t-test
- ✓ Chi-square test for Independence
- ✓ SLR/MLR
- ✓ ANOVA
- ✓ Introduction to Analytics

The present paper tracks a variety of pedagogy changes from 2006 through spring 2014 specifically designed to increase statistical literacy and problem solving by attempting to make statistics real and applied. The syllabus continues to utilize bi-weekly lab assignments designed to solve a statistical problem utilizing larger real life datasets, technology and written summary reports in both the first and second semesters. Second semester business students have always been required to produce a traditional student project in which they ask a simple hypothesis, collect and analyze the data and produce a written project report. Voluntary service-learning (SL) projects were first offered in 2006. These students were required to prepare and present orally. Thus the option of giving an oral report in lieu of a written report was offered to all students. Few students not doing SL opted to present their projects orally; however, those who did presented a better product even when the research design was weak. This initial observation might support mandating all students to present their projects orally, but who has that kind of time in a core course with high enrollment? Maybe “less is more”. Over the years, the lab assignments were continually revised, some SL projects were turned into two-semester SL projects, more media examples were brought into classroom discussions and eventually all students were required to present their projects orally subject to student peer reviews. Through these oral presentations students were exposed to a variety of design settings by their classmates in a real world context serving to develop statistical thinking and provide a natural review of the various statistical tests in preparation for the final exam. Maybe “less IS more”.

Concurrent with these changes in pedagogy, a statistics retention exam was developed in 2009 consisting of 18 multiple choice questions (later reduced to 12) and two written applications problems. One application required the interpretation a two-sample t-test analysis. The other was a simple linear regression problem. In both applications, students were given Excel summary output and asked to interpret the results. Initially, the department used these scores to compare instruction taught in computer labs utilizing technology for statistical analysis to instruction solely in a traditional classroom without formal technology assignments. Retention scores after spring 2010 allowed one to compare retention scores before and after the mandated oral presentations and to compare retention between those self-selecting the two-semester SL and those opting for the traditional student project requirement.

And finally, following the works of Libman (2010) and Newmann, Hood and Newmann (2013), students were simply asked about their perception of the use of real data and their level of confidence in problem solving using statistical techniques on their final exams in both courses in the two-semester sequence. This allowed for observing changes in perception from the first semester to the end of the second semester.

1. Do you think this course made good use of real datasets? Yes No

2. How confident are you in using the tools from this class in developing a research question and using data to investigate the validity of the research question?
   - 0 Not at all confident
   - 1 Maybe a little confident
   - 2 Somewhat confident
   - 3 Very confident

Students' perception of the use of real data was observed through direct questioning as well as extracting the number of students who wrote about using real data unsolicited in their reflection papers after completing the final projects. Reflection papers we required from all students whether they chose to do a SL project or a traditional project.

Timeline of pedagogy changes:

2000:	Bi-weekly labs with written summary reports. Textbook datasets. General student projects with written report only
2006:	Introduced a second semester SL allowing students to choose to participate All students turned in written project reflection; 'real-data' comments
2009 – 2012:	Statistics retention exam was given in upper level required business course
2010:	Mandated oral reporting with student peer review for all student projects A two-semester SL project was presented
2011	Traditional instruction compared to more applied instruction utilizing technology
2013:	Added student survey about real data and confidence in doing statistics

Given this timeline has considerable overlap in when the different pedagogy were introduced, the univariate analysis of comparing student retention for each pedagogy is followed by a multiple linear regression analysis which considers the effects of the three pedagogies simultaneously. In the attempt to control for potential academic confounders, students' course grades and whether the time between taking the course and taking the retention exam exceeded three semesters or not were included in the multiple linear regression modeling.

3. Results

Student learning was measured using a statistics retention exam following at least a summer session break. Univariate analyses measuring the effect of a two-semester SL project, curriculum changes designed to emphasize technology and literacy in written summary reports, and mandated oral project presentations on mean retention scores are described below in Table 1. Students' retention scores following a shift in pedagogy that held the students accountable to using technology and interpreting results through written lab reports significantly increased mean retention scores by 5.3% (one-sided p-value = 0.01). Students' retention scores who participated in the two-semester service-learning project scored on average 6.7% higher than those not participating (one-sided p-value = 0.04). Students' mean retention scores did not improve significantly after requiring all students to present their final projects orally subject to student peer review.

Clearly, one might argue that given the overlap in the timing of introducing the various pedagogies observed in this study, that student retention might simply improve over time as the syllabus is continually adding requirements that meet the GAISE guidelines. Or student retention may simply improve as a result of professional development of the instructor. An

ANOVA analysis did not indicate a significant difference in mean retention scores between students grouped by year they completed the two-semester business statistics sequence.

Table 1: Univariate analyses: P-values are reported for two-sample independent t-tests assuming unequal variances.

Pedagogy	**Mean Retention Score , n**	**One-sided P-value**
After Curr Change	63.5 % , n = 131	0.01 *
Before Curr Change	58.2 % , n = 124	
SL - Yes	67.0 % , n = 26	0.04 *
SL - No	60.3 % , n = 229	
Before Required Oral	59.0 , n = 85	0.11
After Required Oral	61.9 , n = 170	

Table 2 provides a multiple linear regression analysis controlling for the grade the student received in the second business statistics class and the effect of a more than two semester lag between finishing the business statistics sequence and taking the retention exam.

Table 2: Multiple linear regression coefficients given a model that adjusts for student course grades.

Parameter	**Estimate**	**Std. Err.**	**Alternative**	**DF**	**T-Stat**	**P-Value**
Intercept	30.289821	4.1933583	≠ 0	250	7.2232847	<0.0001
284grade	11.074751	1.2360326	≠ 0	250	8.959918	<0.0001
BiLag>2sem	-11.121986	1.9514836	≠ 0	250	-5.6992468	<0.0001
OralCode	3.8574232	2.0681007	≠ 0	250	1.8652009	0.0633

Table 3 shows the results of a paired t-test measuring student's self-reported confidence in performing a statistical analysis from beginning to end comparing their score on a Likert scale (from 0 to 3) at the end of the first semester in the sequence to the end of the second semester.

Table 3: Student Self-reported confidence in performing a statistical analysis.

Paired t-test, n = 60	First Stat Course	Second Stat Course	p-value
Mean Confidence	1.98	2.37	< 0.001

4. Discussion

A two-semester undergraduate business statistics program provides the opportunity to reinforce statistical reasoning taught in a first course of introductory statistics as well as an additional opportunity to bring in real life data and projects. While not entirely convincing, the present study supports that participation in SL is at least not harmful and may positively support learning especially for some types of projects such as the two-semester project considered in this research. A separate analysis collapsing several years of varying SL projects together resulted in a 2.6% increase in mean retention scores for those participating in SL although not statistically significant (P=0.16). Furthermore, after adjusting for the student's second semester business statistics grade and the lag time between taking the course and taking the retention exam, the effect of a SL project drops out of the model. On the other hand, the long term effect of retention following the syllabus change to mandate oral project presentations with peer review becomes marginally significant ($p = 0.06$).

Previously, I reported that students participating in SL projects wrote more freely about working with real data in their reflection papers (Phelps, 2008). This was not observed in the present study. If given the option of responded yes or no to a direct question about working with real data, 96% of all students responded 'yes'. While 7% more students in the SL groups wrote about the benefits of using real data, it was not statistically significant. This could be an artifact of the mandated oral presentations that was added to the syllabus after the 2008 paper cited. Significantly more students in the SL group (51% compared to 40%) did however, write that the project helped them 'learn statistics'. Significantly more students in the SL group (86% compared to 58%) also reported that they would make the same project choice again.

Finally, students reported a significant mean increase of confidence in doing a statistical analysis following the second course in business statistics in which all students were required to present a statistical analysis orally in front of their student peers.

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