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Teaching the Statistics Laboratory – Keep up the PACE

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ABSTRACT

Class research projects have the potential to highlight connections between statistical reasoning and scientific enquiry, hold student interest, and engender creativity in both students and instructors. In the statistics laboratory, we examined a survey research project as a viable alternative to a comprehensive final exam. The project was modeled after the PACE approach (Lee, 1997) focused on Projects, Activities, Cooperative learning, and Exercises. Undergraduate students collected, analyzed, interpreted, and reported survey data then evaluated their experiences. Results suggest the research project effectively and comprehensively tested their statistical skills and conceptual understanding. The project also challenged students intellectually. Although deemed difficult, students would choose the project over a final exam.

INTRODUCTION

Students enter the statistics laboratory from many social science disciplines. The breadth of applications to cover in the classroom requires a focus on practical understanding and utility of methods and procedures. To this end, statistics instructors constantly seek ways to convey material that both engages the student’s attention and provides lasting understanding (Dolinsky, nd; Sowey, 1995).

For students, problem based learning can both highlight the fundamental connection between statistical reasoning and scientific enquiry (Boyle, 1999), and hold student interest (Stork, 2003). Active involvement in hypothesis generation, data collection, analysis and interpretation gives a student the context for learning. Also, real life applications of such learning are more clearly exposed (Anderson & Sungur, 1999). Moreover, innovative teaching assessments help engender creativity in both instructors and students, (Connor, 2003; Gelman, 2002; Wender, 2003).

This survey research project is examined as a validation of Lee's 1997 PACE approach to the teaching of statistics. PACE, or Projects, Activities, Cooperative learning, Exercises, is an effective strategy for helping undergraduate students understand and apply their statistical knowledge and skills. In this project the PACE strategy is applied to a lab survey project that was assigned in lieu of a comprehensive final examination.

METHOD

Participants

Fifty students enrolled in an undergraduate statistics course and co-requisite laboratory at Arkansas State University-Jonesboro (ASU) participated over two consecutive semesters. In one class N=27 and in the other N=23. Ages of students ranged from 18-51 years, with a mean age of 23.58 years (SD 6.04). There were 13 male and 37 female students. Most students were psychology majors**;** other students majored in chemistry, biology, and nursing.

Lab Projects

Project description. Each student was enrolled in one of three lab sections that met once a week for 2 hours across a 14-week semester. Throughout the course, students completed laboratory exercises to practice skills for collecting and analyzing quantitative and nominal data. Additionally, students received extensive instruction on using the statistical software package SPSS, version 11.5.

During a regular lab session in the tenth week of class, students in each lab cooperatively designed a survey on one of three topics: Telephone usage, Internet usage, or Exercise habits among students at ASU. Students generated questions with feedback from the instructor of the course and the laboratory teaching assistant. During this same lab session the instructor reviewed appropriate methods for surveying humans and regulations of the Institutional Review Board for the Protection of Human Subjects (IRB). Students had one week to appropriately format their surveys and submit to the instructor. The instructor reviewed all student work and suggested revisions to ensure comparable survey styles among the three labs. Students revised surveys then the instructor submitted a single IRB protocol with the three survey formats represented. Upon IRB approval, students had two weeks to administer the surveys.

Statistics students haphazardly surveyed 10-20 participants from the ASU student population, 5-10 men and 5-10 women. Survey respondents provided their age and gender and answered questions pertaining to each lab's individual area of interest (Telephone, Internet, Exercise). Two questions on each survey required quantitative responses, such as '*How many hours/times per week do you exercise?*' and one question asked for a nominal response, e.g. '*What type of exercise*?' Surveys included operational definitions of the three interests, Telephone usage, Internet usage, and Exercise.

Once data were collected, statistics students conducted specific analyses on individual data sets. Students also combined their individual datasets to make a large group dataset, one for each lab. Students demonstrated their proficiency in the lab by correctly using SPSS to analyze data from their surveys (but could also complete the analyses by hand if desired). Requisite analyses included both inferential and descriptive statistics using both quantitative and nominal data originating from the surveys. Tests for analyzing inferential statistics included: two independent *t* Tests, one for individual data and one for group data, two one-way ANOVAs, one for individual data and one for group data, two Chi-Square Tests for Goodness of Fit, both from the group data. Additionally, students presented descriptive statistics, comprising one frequency table, two histograms, and a bar graph, each properly labeled with figure legends. Students also submitted a one-page project summary with the results of each requisite test appearing in the appropriate style for a research report.

Project evaluation. Projects were due at the end of the term during the time allotted for a final in the lab. At this time, students evaluated the project in which they responded to a series of questions concerning their experience. First, students identified which of the three labs they participated in and estimated the total number of hours spent working on the project. Then students rated difficulty levels for the statistical procedures on a 5-point scale ranging from 1 (very easy) to 5 (very difficult). Students also rated 20 statements about their experience with the lab project using a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). Finally, students responded whether they would prefer a lab project or a comprehensive final exam if given a choice and some provided written comments.

Using one-way analysis of variance (ANOVA), between groups analyses on quantitative questionnaire data were conducted to identify any differences between the students in the two semesters. Chi-Square Tests for Goodness of Fit were conducted on the nominal preference data. Inter-correlations between statement ratings were examined using Pearson's correlation coefficient. All tests were two-tailed tests and significance was set at $p < .05$.

RESULTS

Significant differences were not observed in any of the response sets between students in the two consecutive semesters. For this reason the results of analyses on the combined data sets are reported.

Hours

Students reported spending a mean of 9.59 hours (*SD* 4.67) on the projects. There was an outlier on this question with one student reporting working 120 hours which increased the mean to 11.59 (*SD* 16.26).

Difficulty Ratings

Descriptive statistics received the lowest difficulty rating while Chi-Squares were rated to be significantly more difficult than other tests, $F(3, 196) = 8.86$, $p < .001$. Post hoc tests using Tukey's HSD revealed that Chi-Squares were rated more difficult than t Tests, ANOVAs, and descriptive statistics (See Table 1).

Table 1. *Mean Ratings for Difficulty of Procedures*

Procedure	Rating	SD
T tests	2.66	1.15
ANOVA	2.62	1.05
χ^2	3.36*	1.08
Descriptives	2.26	1.08

Statement Ratings

Three statements had mean ratings above 4. These were statements on the ability to apply concepts, the project's intellectual challenge, and reliance on textbooks. Statements on understanding statistical analyses and working cooperatively with others also had high ratings whereas statements on the anticipated ease of the project and enjoyment received the lowest ratings. See Table 2.

Table 2. *Mean Ratings on Agreement Statements*

Statement	Mean	SD
I relied on my lab workbook and textbook to help me with this project.	4.41	0.69
I was challenged intellectually by this project.	4.26	0.83
I was able to apply concepts learned in lecture and lab.	4.12	0.59
I was able to work cooperatively with other lab members.	3.96	0.88
I now have a better understanding of statistical analyses.	3.96	0.86
I now have a better understanding of SPSS.	3.92	0.87
I have the skills to perform a similar project in the future.	3.84	0.77
I am interested in knowing how my results compare to the results obtained by others in my lab.	3.82	0.99
I am less anxious about my ability to perform and understand statistics after taking this class and the lab.	3.77	0.68
I had ample time to conduct the project.	3.75	0.78
This project was a valuable learning experience.	3.72	0.64
The knowledge I gained in this project will help me in the future.	3.66	0.72
I would be comfortable discussing this project and my results with someone.	3.59	0.87
Overall, I am satisfied with my performance on the project.	3.58	0.97
I recommend future students perform similar lab projects.	3.48	0.98
Because of the lab, I now have skills desired by future employees.	3.36	0.68
I relied on others to help me with this project.	2.98	1.17
This project inspired me to become involved in research.	2.84	1.06
I enjoyed doing this project.	2.68	1.11

Correlations

Significant correlations existed between several of the statements regarding participants' experience with the lab project. The strongest positive correlations were between statements on student's understanding of statistical analyses and the skills to perform future projects ($r = .64$, $p < .001$); understanding and recommendation to other students ($r = .62$, $p < .001$), and; knowledge gained and less anxiety ($r = .60$, $p < .001$).

One significant negative correlation was observed between statements on easiness of the project and reliance on books (r = -.49, p = .001).

Preference

When asked to choose between a project or an exam, a significant number of respondents chose the project. Of the 44 student respondents to this question 34 chose the project, and 10 chose the exam, X^2 (1, N = 44) = 13.09, p < .001. Students who preferred the lab project cited reasons such as the project eliminated having to cram for a final exam, it allowed them to acquire hands-on experience, and the freedom to use their books and notes as reasons for their preference. A few suggested a similar project earlier in the semester would have been helpful. Those students who would have preferred a final exam commented that the project was too ambiguous and time consuming as reasons for their choice.

Other Considerations

Students had more than 10 days from the last day of the course to finalize their projects. During this time, they could access the computer laboratory and work cooperatively with other students. Approximately 40% of the final lab course grade assessed the students' ability to correctly analyze, interpret, and present statistical procedures and results from datasets.

DISCUSSION

Specific to data analysis, the project exposed students to all the major procedures covered in the co-requisite lecture course: descriptive statistics, *t* Tests, one-way ANOVAs, Chi-Square Tests, and using SPSS. Survey research methods, submitting research protocols for approval by the IRB, and writing a research report were further necessary skills employed for the conduction and completion of the project, each a task less commonly required in a standard statistics lab course.

Survey formats were designed to be simple with minimal questions enabling students to focus on fewer items, and the project's extensive nature gave opportunities for feedback in most skill areas covered in the course. This allowed students to realize their abilities and deficiencies before the end of term and correct knowledge gaps without penalty and also discover the abilities and limitations of their own data.

Results from the project evaluations suggested that descriptive statistics, covered at the beginning of the course and referred to throughout, may have benefited from the timing and repeat exposure. Chi-Square tests, often perceived as easy to conduct, were the last procedures covered in the course and students may have felt the pressures of the ending semester. Additionally, neither the lab workbook nor textbook provided step-by-step instructions for conducting Chi-Square tests for Goodness of Fit with SPSS, a common feature for other requisite tests. Students who perceived the project to be less easy than they had hoped were more likely to rely on textbooks and perhaps other available statistical resources.

This project challenged students and tested their abilities to effectively apply course-learned procedures and concepts. Participants also reported that the project increased their understanding of statistics and fostered cooperation among classmates, a characteristic of good group activities that has been reported previously (Garfield, 1993). Although statement ratings suggest the project was neither easy nor enjoyable, a hindsight majority would select this form of assessment over a comprehensive lab final.

A broader impact was also made as this lab project modeled each aspect of Lee's PACE approach (1997) to teaching statistics with the paradigm's emphases on active engagement of students, relating statistics as a problem solving tool, and involving students in report writing. The focus now becomes getting students to enjoy it!

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