Teaching Statistics With Student Survey Data: A Pedagogical Innovation in Support of Student Learning

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ABSTRACT. Business statistics courses are not typically popular, and students often find the examples and textbook problems tedious and irrelevant. In this article, the author describes a pedagogy project that keeps students interested and working effectively in a large class. Through a student survey, the author gathered data on students’ university experience and demographics. The class used the Statistical Package for the Social Sciences (SPSS) data set for demonstration of a range of statistical techniques. The student survey instrument and data set provided examples and problems for each of the major topics of the course. Student comments and performance demonstrated the project’s positive results.

Undergraduate business students hold two seemingly inconsistent beliefs regarding statistics. The first is that statistics is useful and important in the business world (Stroy, Nauder, & Wegner, 1994). The second is that statistics courses are boring and anxiety provoking (Conners, McCown, & Roskos-Ewoldsen, 1998; Zanakis & Valenzi, 1997). In fact, students and alumni consistently rank statistics courses as among the worst in their business school curriculum (Hogg, 1991; Zanakis & Valenzi, 1997). Nonetheless, most AACSB-accredited business schools include statistics as an undergraduate requirement, with nearly 75% requiring two courses (Parker & Pettijohn, 1999).

Some instructors have responded to negative student attitudes by changing how they teach and what they do in class. A variety of course innovations have been tried and described in the pedagogical literature. Student teams or cooperative learning groups have been used, as have many other student-centered activities, applications, in-class exercises, cases, and simulations (Albert, 2000; Anderson-Cook, 1999; Boger, 2001; Gefman, 1998; Magel, 1998; Marasinghe & Meeker, 1996; Nolan & Speed, 1999; Parr & Smith, 1998; Quinn & Tomlinson, 1999; Smith, 1998; Tryfos, 1999; Watts & Carlson, 1999).

Keeping students actively engaged in class depends, in part, on class size and student maturity. A common suggestion for improving the teaching and learning of statistics is arranging smaller classes (Strasser & Osger, 1995). In reality, however, large classes for quantitative courses are becoming increasingly common (Doran & Golen, 1998), and instructors are being challenged to find pedagogical innovations that work well in large lecture halls. When students have little business or work experience, instructors are further faced with the need to find examples and problems that students find relevant.

In this article, I describe an approach to teaching statistics to a large class of undergraduate business students, most of whom have little work or business experience. A major impetus for the project was student feedback about the examples and problems taught in class and used in the textbook. The following three comments are representative of those student comments: “We need better examples, ones we can understand.” “[The instructor] needs to create stronger examples.” “I felt that better examples would have made the material more clear.”

Project Design

I designed the project to capture students’ interest and sustain it over time in a large lecture class. One of my first project decisions was to abandon the teaching of unrelated exercises and problems in favor of applying continuity across demonstrations, examples, and homework assignments. To this end, I used a single large data set over the course of the semester. My second decision was to use more engaging problems and examples than those found in the typical business statistics textbook. For undergraduate students, analyzing data about themselves, their classmates, and their university experience seemed likely to hold their interest over time. Thus, the pedagogy project process included the following steps:

July/August 2003 335
• designing a survey
• administering it on the first day of class
• giving students a copy of the survey instrument and a data disk
• introducing new topics by using examples from the survey
• demonstrating statistical procedures using student data
• assigning homework based on the survey instrument and the data (and assigning problems from the book for which similar analysis methods could be applied)

The survey instrument itself was critical to the success of the project. It was designed for collection of data at different levels of measurement, so that various analysis methods could be demonstrated. The instrument included several similar questions worded in different ways, so that it could be a teaching tool for introducing topics such as question quality, reliability, validity, and survey design.

I used the in-class survey instrument to collect data on demographics, attitudes, values, and beliefs. Using a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree), students responded to statements about various aspects of their university experience, including several that dealt with their expectations about the statistics course. Students also provided data about summer jobs, TV-watching habits, textbook purchases, living arrangements, and other demographic characteristics. In Table 1, I present some sample items from the student survey.

The questionnaire took students about 15 minutes to complete. I used the responses to create a data file. During the second week of class, each student received a copy of the survey instrument and a data disk. To promote consistency and avoid confusion, I included variable names, variable labels, and value labels in the data set.

Of the 80 students registered for the course, 78 were present on the first day of the semester and completed the survey. Majorities of the respondents were male (57%), lived on campus (63%), and held a part-time job during the school year (74%). Most (82%) were between 19 and 21 years old. Most believed that statistics was useful in business, and most expected to use statistics sometime at work (see Table 2). Only a third agreed that math was fun, and less than half expected to do well in the statistics course.

### TABLE 1. Sample Items From the Student Survey

<table>
<thead>
<tr>
<th>The university</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offers a good selection of courses.</td>
</tr>
<tr>
<td>Has good food service.</td>
</tr>
<tr>
<td>My professors</td>
</tr>
<tr>
<td>Seem eager to be in class.</td>
</tr>
<tr>
<td>Know their material.</td>
</tr>
<tr>
<td>Students at the university</td>
</tr>
<tr>
<td>Are friendly.</td>
</tr>
<tr>
<td>Work hard in school.</td>
</tr>
<tr>
<td>In my experience at the university, I have enjoyed most of my courses.</td>
</tr>
<tr>
<td>Have found it difficult to make new friends.</td>
</tr>
<tr>
<td>On the first day of this course, I believe that statistics is useful in business.</td>
</tr>
<tr>
<td>Think learning statistics will be hard.</td>
</tr>
</tbody>
</table>

*Note: Students responded to statements on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree).*

### TABLE 2. Statistics-Related Attitudes and Expectations of Students

<table>
<thead>
<tr>
<th>Survey statement</th>
<th>Students agreeing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think I will do well in statistics.</td>
<td>34</td>
</tr>
<tr>
<td>I believe that statistics is useful in business.</td>
<td>34</td>
</tr>
<tr>
<td>I think learning statistics will be hard.</td>
<td>34</td>
</tr>
<tr>
<td>I think math (in general) is fun.</td>
<td>34</td>
</tr>
<tr>
<td>I expect to use statistics at work sometime in my career.</td>
<td>34</td>
</tr>
<tr>
<td>I am comfortable with computers.</td>
<td>34</td>
</tr>
<tr>
<td>I know how to use Excel (or some other spreadsheet program).</td>
<td>34</td>
</tr>
</tbody>
</table>

*Combines % who answered agree and % who answered strongly agree.*

### Analyzing the Data in Class

Upon receiving their data disks and survey instruments, students were immediately interested in generating questions that they thought could be answered through the survey data. Over time, they were also expected to identify the procedures that should be used to answer their questions. Throughout the course, I modeled the process by posing a question and then explaining why a particular statistical technique was selected for analyzing the data and answering the question.

For each of the major course topics, questions were formulated and answered through use of the student survey data. The course used the Statistical Package for the Social Sciences (SPSS) to demonstrate all statistical techniques.

### Data Collection

As Zeis, Shah, Regassa, and Ahmadian (2001) urged, I “put the horse before the cart” (p. 83) in this statistics course by starting with data collection, reserving the discussion of analysis and inference until later. Students began the course by learning about types of data, levels of measurement, operational definitions, and so on. Using the questionnaire, they found examples of well-written questions and questions with ambiguous or problematic wording. They discovered how difficult it is to interpret results when variables have not been defined operationally very well.

A simple example related to the number of hours worked in the summer.
Students generated several possible interpretations of the following statement: “During the summer, I worked an average of _____ hours per week.” Did this refer only to paid work? Should paid babysitting hours have been included or only hours at a “real” job? Were volunteer hours supposed to count? What about hours worked for summer classes? Students concluded that how a question is asked matters a great deal, even when “objective” data are being collected.

Tables and Charts

After the unit on data collection, the focus shifted to data tables and charts. Using the student survey, I designed visual displays. We used questions that students found interesting in discussions and demonstrations. For instance, we constructed a bar chart by using student responses to the statement “The university’s food service is good.” When SPSS results were displayed on the overhead screen, students were captivated by this example. They seemed surprised that so many of their classmates had agreed that the food service was good.

Descriptive Statistics

The next section of the course focused on summarizing and describing numerical data through the use of survey items that had generated ratio-level data. The class used responses to “I watch _____ hours of television per week” to calculate descriptive measures of central tendency, variation, and shape. Students used similar examples to do exploratory data analysis and to learn about box-and-whisker plots.

Basic Probability

Using survey results, the students began to study probability by answering simple questions such as, “What’s the probability that a student in this class lives on campus?” From there, I introduced more complicated questions through use of concepts such as joint, compound, and conditional probabilities. The class used SPSS to generate cross-tabulation/contingency tables. Students used the tables to find the probability of living on campus and being happy with current living arrangements, as well as the probability that on-campus students are happy with their living arrangements.

One example that students found very interesting involved responses to the statement “I think learning statistics will be hard” and “I think I will do well in statistics.” The 5-point scale was recoded as Yes/No and displayed with gender (Male/Female) in contingency tables. Before I projected results on the overhead screen, students “guessed” what the results would be, and the class briefly discussed math anxiety and gender stereotypes. Contingency table results showed that (a) a higher proportion of women in the class thought statistics was going to be hard and (b) a smaller proportion thought they would do well in the course. Students were captivated by this example. They seemed to appreciate the difference between marginal and conditional probabilities and to understand what independence means; they realized that gender and these particular math attitudes were not independent.

As a follow-up to this class demonstration, I also presented later test scores with gender in contingency tables. Students could see that the probability of a female student scoring 80 or higher (the class’s definition of “good performance”) was greater than the probability of a male student scoring 80 or higher. Students were very interested in discussing the seemingly inconsistent tables for gender and performance expectations and the tables for gender and actual performance.

Probability Distributions

As they moved into more sophisticated probability topics, the students used a number of variables to develop probability distributions. Variables such as gender and job status were easy to use in binomial examples. Students answered questions such as, “Given that 60% of this class (the population) is male, what is the probability that in a random sample of eight students, six will be male?”

I taught the normal distribution by using variables such as current GPA, hours of television viewing per week, hours of work per week, and overall satisfaction with the university (measured on a 100-point scale). Using SPSS, students examined the shape of different data distributions and computed descriptive summary measures. When they needed to make comparisons across variables and distributions, students learned the importance of standardized normal distributions and standardized scores.

Sampling Distributions

With this relatively large data set, students were able to draw repeated samples to construct sampling distributions of the mean for variables including current GPA, hours of television viewing per week, hours of work per week, and overall satisfaction with the university. They used samples of different sizes to discover the effect of sample size on the clustering of means. So that students would understand the power of the central limit theorem and its implications in statistical analysis, I included some variables that were far from normally distributed.

Interval Estimation

The class used different-sized random samples taken from the population data set (the statistics class) to estimate population parameters (albeit for a population with known parameters). Students were able to use sample statistics and population parameters to explore the concepts of interval estimation and confidence levels. They calculated interval estimates for means and standard deviations for age, money spent on books, and GPA and constructed confidence interval estimates for proportions by using data from several of the agree/disagree statements of the survey.

After defining the class as the population, students also treated it as a sample of university sophomore students. (The limitations of using this class as a sample were discussed.) Students worked with questions such as, “Given that 28.2% of our sample agreed that the university food service was good, what is our 95% confidence interval estimate for the proportion of university sophomores who would also agree?”

July/August 2003 337
Hypothesis Testing

In one of the most vivid hypothesis-testing demonstrations, I used the survey data to teach about Type I and Type II errors in one-sample tests. Because samples had been drawn from a known population, students could see the errors that they made in rejecting or accepting the null hypothesis. They could see what happened as alpha (the $p$ level) was adjusted and as the sample size was varied.

Two-Sample Comparisons

Using $t$ test procedures, the class compared mean responses for two independent samples (men and women) and then examined reported differences in GPA, hours of television viewing, and other characteristics. By drawing multiple samples, students had first-hand experience with sampling errors. They came to understand what “statistical significance” implies and what it does not imply.

The male-female samples used in $t$ tests were also used for demonstrating simple analyses of variance (ANOVA). After working with the two-group case, students did not find it difficult to use ANOVA to look at main effects across more than two groups. The class looked at GPA data for students in different majors to examine “major” effects on GPA. Two-way ANOVA procedures were demonstrated through gender and major. Both main effects and interactions were discussed.

I used survey data to demonstrate how to test for differences in two proportions based on independent samples (chi-square). Students were already familiar with contingency tables that had been created in the probability portion of the class (for men and women and expectations about learning statistics). In this section of the course, the class analyzed the same proportional data for significance through chi-square analysis.

Correlation and Regression

The final topics of this course were correlation and regression analysis. The use of our survey data made explanation of the difference between causation and correlation relatively easy. Although students could find statistically significant associations between items (e.g., between students’ views about the university computer system and faculty eagerness to be in the classroom), they could not “explain” the significant association. With a simple example like this, students could understand the difference between correlation and causation.

Several approaches to predicting GPA and overall satisfaction were demonstrated. First, the class used variables one at a time; later, students used several together. For the independent variables, students chose items such as hours of television watching, hours of work, satisfaction, age, and so forth. Students worked with these data to learn about residual analysis and to estimate predicted values. They developed more complicated linear models by including categorical variables such as major and gender.

Homework and Tests

During the semester, I offered students homework choices; they could do problems from the book, or they could do similar problems using the student survey data. Nearly 75% of students regularly chose to do survey data homework, even though they knew tests would include business application problems. I designed survey homework problems to match textbook homework problems in difficulty and analysis. Students who did the survey homework problems reported that those were more fun than the ones in the book and easier to learn from. Working with data set that they knew very well seemed to enhance their confidence and their perceived competence.

Because this course was a business statistics course, I devoted some class time to demonstrating statistical approaches to business application problems. Students also had one recitation class per week with a teaching assistant who went over textbook problems. Students prepared for tests knowing that they would include mostly business application problems. (Test results for the semester preceding this project semester and for the project semester showed no difference in student performance on tests. Students reported greater confidence, however, in their learning and performance during the project semester.)

Faculty and Student Reaction

From my perspective, this pedagogy project was a teaching success. It allowed for greater continuity and an ongoing conversation with students. It made new concepts and techniques easier to teach, and it seemed to make statistics more accessible to the students.

There were two sources of reaction data indicating the students’ perspective, and both suggested a very favorable response. First, the end-of-semester course evaluations showed improvement in scores that should be associated with the innovation. The $t$ test results for items such as effective use of class time ($t = 1.42; df = 93; p = .08$) and clear transmission of knowledge ($t = 1.55; df = 93; p = .06$) show change in the hypothesized direction, although not quite at the .05 level of significance. At the same time, evaluation scores that should not have been affected were unchanged. The $t$-test probabilities were between .18 and .45 for items such as “The instructor shows concern for students,” “The instructor is open to relevant class discussion,” and “The course was well organized.” Second, students’ informal comments as well as their end-of-semester evaluation feedback suggest that they really enjoyed being able to work with a single data set and that analyzing data about themselves and their classmates did indeed hold their interest over time.

REFERENCES


Doran, M., & Golen, S. (1998). Identifying communication barriers to learning in large group


