STATISTICAL CASES TO INCREASE LEARNING AND MOTIVATION

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Short cases which include a problem context and real data sets are used to improve the teaching and learning of statistics. Students develop analysis and writing skills and also are motivated to learn statistical methods. Students work in teams of two using a computer for analysis and preparing written reports. Increased interaction between students and between students and faculty provide a dynamic learning environment. An increased student work load is combined with a high level of student satisfaction.

This paper reports on our work in using cases to improve teaching and learning in introductory statistics classes for students in business and economics. But the approach has application to most introductory classes. The key is to create realistic applications which provide students with practice in analysis and reporting their results, which in turn provides positive motivation for learning statistical methods.

Knowledge of statistical methods is becoming increasingly important for economics students. Applications for increasing productivity, improving quality, marketing and policy are rapidly expanding in all economic sectors. Improved statistical computer packages and the explosion of electronic data sets have expanded the opportunity for statistical applications. At the same time teaching statistics has become increasingly difficult and frustrating. Students now, compared to previous generations, are more reluctant to follow long mathematical developments of statistical concepts. However, by using realistic data based cases in our classes, students become interested in the application. They learn how to apply statistical methods to economic problems and how to report their results. In the process of preparing a solution they learn statistical methods.

The practice of bringing realistic applications and cases into economic and business education is growing in general (Siegfried et al 1991, Schodt et al 1995) and particularly in statistics classes (Becker 1996, Hilmer 1996, Carlson and Smith 1997). This growth should not be surprising if I reflect on my own reasons for initial interest in economics and statistics. Most of the people I talk with were and are excited about the applications. Students have the same reaction. They are motivated by case applications and case work provides an excellent learning environment.

CASE APPLICATIONS

My use of cases has followed a long evolutionary process. I began in 1973 by asking students to find a   data set, run a series of regressions, and report the economic conclusions. This led eventually to a collection of data sets from business and government applications. These data sets were used initially with a series of questions which grew to short cases.   Finally in the past four years I have written a casebook with a series of short (three or four page) cases which describe a problem and its context. Students are supplied with a data set and guidelines for developing their solutions. Over the years the teaching philosophy has evolved from merely providing statistical applications to the learning benefits from the interaction between student motivation, development of statistical analysis capabilities, and the preparation of written reports. These cases provide a problem environment whose solution requires identifying and applying appropriate statistical methods and reporting the results.

The context for my use of cases is a course designed to emphasize applications and the derivation and assumptions which underlie statistical methods.   Statistical methods are introduced and discussed using specific applications without sacrificing the underlying mathematical language. The first case, which is assigned after the second or third class, requires only simple descriptive statistics.   Assigned cases increase in difficulty as student skills increase over the course. For the early cases students are given an analysis procedure and specific instructions for case analysis. As the course proceeds the emphasis is shifted to student preparation of a report. This report uses results from their statistical analysis communicated in a form for managers who were not statisticians. Some cases can be analyzed at several different levels with the more complex questions left for the end of the semester. I ask students to work in teams of two so that they can learn to work in teams and learn statistical procedures from each other as their project develops.

Students are encouraged to begin writing their report before they have completed their statistical analysis. Writing is an analytical process, which helps students identify statistical procedures that are required to produce recommendations. Then as the analysis develops written discussion and statistical outcomes—computed output, graphs, tables— are added to the written report. At the end of the analysis the student can focus on refining the report, stating conclusions, and preparing an executive summary, which is placed at the beginning of the report. (Carlson, 1997(2))

Teacher comments on student reports are an important part of learning in this class. Typically students receive number of negative comments on their first paper - most dealing with appropriate writing and presentation. Simply responding to questions in the case does not lead to a good grade. After several cases students learn how to prepare reports and by the end of the course most student reports are of high quality. I believe that requiring a number of short reports with individual feedback is a better way of developing student analysis and writing skills, compared to one long paper at the end of the semester.

A continuing question in case design concerns the amount of direction provided students. I believe that initially students should be provided guidelines which help them learn good analysis methodology. However ambiguity forces students to ask questions and make analysis decisions, which also contributes to their learning. My approach is to provide detailed questions and guidelines for the first two or three cases and to emphasize the report for later cases. Discussions with other teachers indicate considerable variation depending upon the class objectives and student experience.

Data sets in computer accessible form are provided instead of requiring that students collect their own data. Learning good data collection procedures is clearly important. However, considerable time is required to do it correctly and I do not want to provide a situation in which students learn bad data collection habits because of limited time for data collection. Thus I believe that more is gained by having students emphasize analysis and writing in their cases.

Modern microcomputer based statistical packages reduce the computational barrier. The menus in modern graphical user interfaces provide natural paths and allow students to quickly search for statistical procedures. Thus emphasis can be placed on choice of proper statistical procedures and their interpretation in a problem solving context. It is also easy to transfer statistical output to a text editor. This provides a smooth and natural environment for writing about statistical analysis and for preparing recommendations from the analysis. Removing the computing barrier enables greater concentration on problem solving, which implies greater educational productivity.

ASSESSMENT

Cases in their present form have been used in our classes for the past four years. Each semester students are asked to evaluate the course and its use of cases. A large

majority of the students (80 to 90 percent) each semester respond favorably to the case approach. Students complain about the higher work load compared to their other classes, but insist that the increased learning is worth the additional effort. Similar experiences with these same cases have been reported for students in an MBA program (Drapeau 97).

Analysis of student test data from the past four years indicates that student grades on case projects are statistically significant predictors of examination grades. Case project grades are based on the quality of the applied analysis and effective communication of results in a written report and not particularly on the understanding of statistical methods. Case project grades are also based on the work of a two person team. In contrast examinations are based on student understanding of statistical methods. Thus there is evidence that the quality of student performance on case projects is directly related to the understanding of statistical methodology. Some teachers of applied statistics argue that it is better to trade reduced understanding of statistical methods for increased application and writing skills. Initial results indicate that such a trade is not required. Good practice leads to good theory!

CONCLUSION

The approach presented here emphasizes student involvement and motivation by having students work in realistic problem solving situations. Several points are, I believe, key to this approach. Students need to have good statistical methodology presented throughout the course. But I do not wait until they have mastered methodology before providing realistic problem solving situations. Statistical methodology and problem solving are learned simultaneously while students struggle with realistic problems. Assigning cases while students are learning concepts provides a clear connection between the importance of statistical understanding and good problem solving and provides strong motivation for students. The motivation results from a realization that good statistical practice can provide important contributions for solving economic problems and providing policy guidance.

Introductory statistics courses often involve considerable work and contribute to student anxiety. So if I add cases to a course what will I give up? One approach is to reduce the number of statistical topics covered and argue that it is better to have applied mastery over fewer topics. In our case I have reduced, but not eliminated, the number of

homework problems assigned. Thus student case project work   requires that they simultaneously practice the skills involved in typical homework problems.

I have used my own casebook to implement the approach presented here. One could also use data and problems from personal research and consulting, but developing realistic cases requires considerable effort over many years. Whatever the specific structure learning is improved by student involvement in problem solving.
Our use of cases has generated considerable direct interaction between faculty and students.   For our small classes (15 to 30 students) I assign a student assistant for four hours each week to work in the computer laboratory.   The student assistant answers questions and is available to read drafts of student papers and provide guidance for improving their writing. In addition I am available on a regular basis for consultation with students. These direct interactions are the most effective learning component in the course.   Students come with questions after they have thought about the problem for a while and after they have reviewed what they already know about statistical methodology. In this context students are receptive to understanding the statistical concepts discussed in these short conferences.   Thus a short case problem discussion with students may contribute more to learning than several hours of lecture.   My experience is that class preparation time is reduced and student contact through consultations, e-mail questions, and paper grading are increased.

Grading project reports requires additional time because one is reading reports and not merely grading problems.   Student reports can take different—equally correct— approaches. The grader must be able to recognize creative solutions, but also identify and provide criticism, which assists learning, for incorrect solutions. The grading provides an excellent opportunity for student feed back. Requiring students to work in teams of two reduces the volume and makes the task feasible.

REFERENCES

Becker, W. E. (1996). The Teaching of Statistics and Econometrics as Part of the Undergraduate Economics Curriculum: An Argument for Using Real Examples from the Popular Press. Oxford OH.   Miami University.
Carlson, W. L. (1997). *Cases in Managerial Data Analysis*. Belmont, CA: Duxbury Press.

Carlson, W. L. and Thorne, B. (1997). *Applied Statistical Methods for Business, Economics, and the Social Sciences*. Upper Saddle River, NJ: Prentice Hall.

Carlson, W. L. and Smith, M. (1997). The Use of Case Studies in Statistics Courses (workshop). Making Statistics More Effective in Schools of Business: Technology, Learning, and Statistics. University Park, PA. Penn State University.

Drapeau, R. (1997). A Case Method Approach in a Required MBA Statistics Course. Making Statistics More Effective in Schools of Business: Technology, Learning, and Statistics. University Park, PA. Penn State University.

Hilmer, S. C. (1996). A Problem-Solving Approach to Teaching Business Statistics. *The American Statistician, 50(3),* 249-256.