ON TEACHING STATISTICS TO NON-SPECIALISTS: A COURSE AIMED AT INCREASING BOTH LEARNING AND RETENTION

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Unfortunately, students in required service courses rate them very poorly and neither learn nor retain much of the statistics that they do encounter. These courses would be more highly rated by students and both learning and remembering enhanced by designing instruction in accordance with recent research findings and, in particular, points involving subject structure and worthwhileness. To this end, we describe a course we use that is: (1) embedded in a decision-making context that assumes problems are client-driven; (2) computer-based; and (3) designed with a conceptual umbrella over empirical assignments. The course encompasses the selection, use, and interpretation of statistical tools in conjunction with the effective presentations of results aimed at supporting practical decision-making.

THE PROBLEM

Statistics is a required course for students in a broad range of disciplines at both the undergraduate and graduate levels (Gordon, 1995) Sowey (1995), notes that it is in these service courses that one finds the majority of statistics students. It is, fortunate, indeed, that statistics has so deeply penetrated higher education worldwide in that: " There is near-universal consensus that statistical literacy and appreciation is an important component of undergraduate and graduate education in all fields involving the gathering, interpretation, or presentation of data." (Yilmaz (1996: 1). Unfortunately, evidence strongly suggests that the students in these courses are not particularly happy to be there (Dillon, 1982; Hogg, 1991; Snee, 1993; Watts, 1991) and, in fact, students often rate them as the worst course or the most useless course they have ever taken (Romero et al., 1995). Perhaps even more unfortunate, students neither learn nor retain the statistics they do encounter (Hogg, 1991; Snee, 1993; Sowey, 1995; Yilmez, 1996).

TOWARD SOLUTIONS

Given the importance of statistics and the unhappiness and lack of learning on the part of students taking statistics courses, it is not surprising that a number of relatively recent studies have been aimed at the improvement of statistical education. A number of solutions have been offered for improving courses in general and service courses in particular. Some proposed solutions are based on judgment, some on experience, some on learning theory, and some on experiments (Cobb, 1993; Fillebrown, 1994; Gal and Ginsburg, 1994; Garfield, 1993, 1995; Gordon, 1995; Hy and Hughes, 1988; Keeler and Steinhorst, 1995; Konold, 1995; Moore, 1988; Nash and Quon, 1996; Romero et al., 1995; Snee, 1993; Sowey, 1995; Steinhorst and Keeler, 1995; Sweller, 1989; Yilmaz, 1996).

REAL WORLD PROBLEMS

Along with others, we believe that some of the dislike students have for statistics service courses is based on the fact that the students are not adequately shown why statistics is useful (Keeler and Steinhorst, 1995; Romero et al., 1995; Sowey, 1995; Yilmez, 1996). This issue takes a number of different forms, but a common one is that students are not provided "real-world" problems on which to work. The approach we use involves real world data and problems. The preferred data set is built around a survey of students. The students work with this data set throughout the course.

EMPHASIZING CONCEPTS OVER COMPUTATIONAL MECHANICS

We also agree with others that students also dislike these courses when there is an emphasis placed on computational mechanics and students are required to manually work through sets of calculations involving the formula for statistical measures and tests (Gal and Ginsburg, 1994; Keeler and Steinhorst, 1995; Steinhorst and Keeler, 1995; Watts, 1991). Like the preceding issue, this one can take a number of different forms, but a common one is that students are not encouraged to develop conceptual skills and to critically and actively work with and think about statistics. There is clearly little need to continue emphasizing mechanics given the capabilities and availability of statistical and related software and the ability of students to use these products (Garfield, 1995; Nash and Quon, 1996). Thus, instead of having students do manual computation, we use a statistical analysis package.

WRITING AND PRESENTATION SKILLS

While we do not focus on computational mechanics, we do focus on the "mechanics" of other skills, namely those of writing and presentation. We agree with Hy and Hughes (1988) that writing and speaking are fundamental skills required by students in that are found in the "literacy" component, which is one of the three components (the other two being critical thinking and the understanding of numerical data) that students must possess.

ACTIVE COOPERATIVE LEARNING

We also agree with Keeler and Steinhorst (1995) that students tend to prefer a cooperative form of "active" learning and that when this is not present, students tend to dislike a statistics course. Garfield (1995) argues that "active" learning by students who are working cooperatively in small groups also improves their learning of statistics. We allow (not force) students to form groups of their own choosing to work on the assignments. We have each individual student turn in assignments separately but , if applicable, identify the other members in their work group.

SELECTING A SET OF SOLUTIONS: STRUCTURE AND WORTHWHILENESS

There are, of course, many more proposed solutions for providing value to students in statistics courses so that they learn and retain what they do encounter. Clearly, however, even if we had the time and space to list them all here, it is unlikely they all could be implemented in a given statistics course, given time and other constraints that affect instruction. Fortunately, however, there are course-dependent if not universal solutions. Accordingly, our proposed solution is most salient for undergraduate students majoring in business administration who have experience in using products such as spreadsheets and word processors. In designing our solution, we find that the points made by Sowey (1995) are the most salient. Namely, that statistics becomes memorable when students have a sense of its "structure" and its "worthwhileness." That is, statistics will be valued by students when: (1) they can see it from a "vantage point;" (2) it is shown to provide intellectual excitement; (3) it is found to be resilient to challenging questioning; and (4) it has a demonstrated practical usefulness. Consequently, we argue that a focus on concepts, practice, and presentation is important for students in the types of service courses we describe. From the standpoint of Sowey's point about "structure" it is extremely important to give the course an overall focus. We choose "decision-making" for this focus. We use case-studies and real-world problems to augment this perspective (Romero et al. 1995). and do so in an "active-learning" and cooperative environment (Steinhorst and Keeler, 1995).

A STATISTICS COURSE FOR BUSINESS ADMINISTRATION STUDENTS

Business administration students will gain a strong vantage point on statistics if it is taught to them as a decision-making science with an empirical orientation. In our course, we examine, with the students, the use of statistics in supporting practical decision-making while minimizing cost and time involved in developing the information used to make decisions. We also teach statistics through the use, interpretation and effective presentation of information related to inferential statistics in support of practical decision-making. The approach we take is designed to provide students with an understanding of basic descriptive and inferential tools to answer questions and efficiently fulfill informational needs. It embeds these tools firmly within a decision-making framework. Inferential statistics is presented as a rule-based method of decision making in the face of a particular type of uncertainty, namely sample error. Our course is empirical, which means that students will gain an understanding of these tools and their appropriate use by applying them to case study data. Through this approach, a student can examine the theoretical foundations and uses of these tools through a combination of logical and computer-based analysis. Further, although mathematical formulae are presented and discussed in terms of their underlying logic, we do not require students to memorize them. Instead, we examine the tools critically, which shows they are "resilient," in Sowey's (1995) sense, to challenges.

HOW DO WE PRESENT "DECISION-MAKING?"

Our course emphasizes that statistical analysis has as its sole and immediate aim that of assisting a decision maker with a concrete practical decision. A corollary is that the process is client-driven -- the definition both of the problem and of an adequate answer are determined primarily by the decision maker, i.e., the client, and not by the analyst or by statistical research traditions (Mosteller, 1988). We compare the "applied" approach taken in the class with the "theoretical" aspects of statistics. This gives us the opportunity to point out that the guiding principle in applied statistics for decision-making is *quantum sufficit* - only as much as necessary for the immediate problem at hand. We do not fully go into the tenets of Decision-making Science. We present a heuristic device to students that assists them in getting an idea of the applied, practical dimensions of decision-making - the "triple constraint perspective" (Rosenau, 1981), which includes three dimensions: (1) a performance specification - the explanatory/

predictive precision sufficient to support a given decision-making situation; (2) time - the schedule requirements under which the performance specification must be accomplished; and (3) resources - the budget requirements under which the performance specification must be accomplished.

COMPUTER-BASED INSTRUCTION

There are many excellent statistical packages available. However, we use the NCSS package (Hintze, 1995). We do so for several reasons: (1) It is constructed on a spreadsheet platform (EXCEL) and Nash and Quon (1996) provide a long list of persuasive arguments on the advantages of using spreadsheets in statistics courses; (2) The online "help" system and the User's Manual (Hintze, 1996) are consistent with the tenets of cognitive load theory, which greatly improves the learning process (Chandler, 1996; Sweller et al., 1990); and (3) NCSS provides "real" data sets as an integral part of the package, which offers alternatives to our preferred data set.

ANALYSIS AND PRESENTATION

Our course requires students to go through the process of collecting data, constructing a "clean" data file, and using inferential statistics to analyze the data in order to support a "decision." In the process of going through these steps, the students write reports and give presentations. Because of time constraints in the course it is not feasible to have each student give an individual report. This is where cooperative group learning is of great assistance because students in a given group can cooperate in the writing and give a joint presentation. This is a common situation for business administration students since they often deal with case study problems in groups. If class size is small (say less than 20 students), it may be feasible to have individual presentations. The "open book, open-note" nature of the exams, encourages students to maintain a comprehensive and organized set of notes. Coupled with the papers that they write, this represents a resource that the students are strongly encouraged to retain for future use. It also reinforces the "writing" emphasis.

SUMMARY

Our course was first implemented with many of the same features described here. It began as a computer-based course using real world problems that emphasized active learning. It has been refined and revised over a period of ten years and adapted to serve students representing a wide range of disciplines. The course has consistently received strongly positive evaluations from students. Most recently, for example, at the International BBA program of the Helsinki School of Economics and Business Administration, this course has received an average rating of 8.85 (out of a possible 10 points, n=2) compared to an average rating of 7.72 points for courses not designed in this manner (out of 10 possible points, n=7). More Importantly, informal evidence indicates that the students not only learn concepts but retain a "structural" picture of statistics that allows them to quickly regain a good understanding of individual aspects of statistics.

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