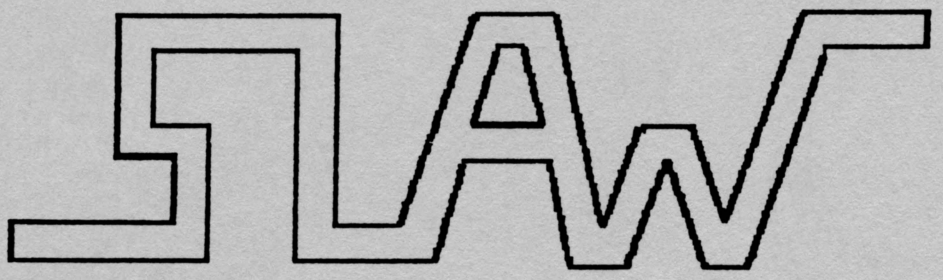

APPLIED INTRODUCTORY STATISTICS COURSES FOR MATHEMATICS MAJORS AT LIBERAL ARTS COLLEGES

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ABSTRACT

The need for an applied introductory statistics course for mathematics majors at liberal arts colleges is discussed. General characteristics for such a course are given and specific examples are described in the papers that follow.

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1. INTRODUCTION

In a discussion of the status of statistics education at liberal arts colleges, Moore and Roberts (1989) point out the need for a course in applied statistics that is designed to motivate mathematics students to study statistics further. While this need is not unique to liberal arts colleges, it is particularly important at small colleges where statistics offerings are limited. Currently at these colleges mathematics majors first encounter statistics in a mathematical statistics course that has several prerequisites. Thus a math major's introduction to statistics is delayed, often to the junior or senior year. The need for an applied course to introduce mathematically able students to statistics earlier in their undergraduate careers is further discussed in this paper, and the general characteristics of such a course are documented. Several implementations of applied courses are described in papers that follow.

2. STATISTICS EDUCATION FOR MATHEMATICS MAJORS

The statistics offerings at liberal arts colleges are typically limited to introductory service courses and a two-term sequence in probability and

mathematical statistics. (Moore and Roberts, 1989.) While mathematics majors are not precluded from taking the introductory course, they are implicitly discouraged from doing so by the fact that it rarely counts for credit toward the major. Thus most graduating mathematics majors have had little or no exposure to the applied side of statistics.

The students we see in the mathematical statistics course usually have very limited experience with data. Trying to make amends for this within the context of a mathematical statistics course is not easy. There is already more than enough material to cover if an adequate introduction to the theory and methods of statistics is to be given. While textbooks are now including real data in examples and problems, this does not provide sufficient exposure for students to develop an appreciation of data. Even the inclusion of an introduction to data analysis is insufficient, because the amount of time that can be devoted to this is limited.

For these reasons, we see the need for an applied course for mathematics majors. There are two general requisites for this applied course. ***First, the course should be taken preferably before, but at least concurrently with, the mathematical statistics course.*** There are several reasons for this. From a pedagogical point of view, we believe that our students will benefit much

more from the mathematical statistics course if they have a prior appreciation of data. From a practical point of view, delaying such a course until after the students have taken the mathematical statistics course will unnecessarily reduce the number of students eligible to take the course. Additionally, if the course is an entry level course to the mathematics major, it may attract students to the major.

Second, the course must count for credit toward the mathematics major. This may be problematic for mathematics departments in which applied work is not considered to be legitimate mathematics. However, if mathematics departments are including statistics in their offerings, they have an obligation to recognize that statistics has both theoretical and applied components. If they fail to do so, statistics as a discipline is not fairly represented. Data are at the heart of statistics, and without experience with data, our students' statistics education is deficient. No wonder so few students are motivated to pursue a career in the subject!

3. THE GOALS AND CHARACTERISTICS OF THE APPLIED COURSE.

The primary goal of the applied course we are proposing is to develop in students a "data sense" through experience with real data. It is only through this kind of experience that students learn that data don't exist on their own, but within a context. The context gives rise to the reasons the data were collected, the way in which they were collected, and the questions they were collected to answer. Students must learn how to formulate these questions precisely, how to plan the data collection so that these questions can be answered efficiently, how to verify the data, and finally how to analyze the data. Emphasis must be placed on the dialog between the data and the model used during the analysis so that students learn that understanding data is an iterative process. It is this dialog that characterizes statistics and distinguishes it from the deductive thinking characteristic of mathematics.

There are several possible models for an applied course that can meet this goal. One model is to have a substantial data analysis supplement to an existing probability or mathematical statistics course. Witmer describes such a supplement in a following paper. This supplement could be offered

as a stand alone unit in a 4-1-4 system.

Another model is to make the course specific to some statistical methodology. In the following papers, implementations of two such courses are discussed: Lock describes a course in applied time series, and Wolf a course in applied multivariate analysis. In addition, Cobb (1984) describes an elementary approach that forms the basis for a course in the analysis of variance. In deciding on the statistical methodology for the course, careful consideration should be given to prerequisites since they will determine when in a student's career the course can be taken. It might, for example, be possible to offer a course without linear algebra as a prerequisite by incorporating the necessary matrix algebra into the course. We note that since the course is to serve as an introduction to statistics, students should not be expected to have taken a previous statistics course.

An integral part of any of these applied statistics courses is the use of a computer. This is a necessary tool for the analysis of large data sets, and essential if we want students to get an accurate feel for how a statistician works. Use of a computer does not preclude some hand computation, nor does it make the course one in statistical computing. Rather the computer is used as a powerful tool that allows students to give their attention to the

interpretation of the data and to the underlying statistical concepts.

Another component that may be given more or less emphasis is the inclusion of oral presentations and written work. Users of statistics must be able to express clearly the results of an analysis, often in non-technical language, yet this type of communication is not usually taught. The emphasis on understanding data in this applied course makes it an ideal place to include written and oral communication in the statistics curriculum. Radke-Sharpe (1990) discusses the benefits of including written work in a statistics course, and gives specific implementations.

4. DISCUSSION

The applied courses described above add a new dimension to the statistics education of mathematics students at small colleges. They augment the statistics offerings for mathematics majors and expose students to the excitement of working with real data. While this experience may also be gained from introductory statistics service courses, the latter are usually designed with very modest mathematical content that is unlikely to challenge most mathematics majors. We aim, by adding such a course to the un-

dergraduate curriculum, to broaden the statistics education of mathematics students, better equipping them to understand the world, which is one of the goals of a liberal arts education. We also hope, by exposing mathematically able undergraduates early to the applied side of statistics, to encourage more and better qualified students to pursue statistics as a career.

REFERENCES

Cobb, G. W. (1984), "An Algorithmic Approach to Elementary ANOVA," The American Statistician, 38, 120-123.

Moore, T. L. and Roberts, R. A. (1989), "Statistics at Liberal Arts Colleges," The American Statistician, 40, 80-85.

Radke-Sharpe, N. (1990), "Writing as a Component of Statistics Education," submitted to The American Statistician.