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ABSTRACT

This paper discusses the problems and general solutions of statistics teaching by summarizing some strategies that have been effective with part-time students in off-campus settings. Included are discussions on: (1) applications of computer skills and student projects; (2) teaching statistical thinking using various modes of presentations and introducing new topics with a review of the prerequisites; and (3) textbook issues including lecture notes and student study groups. A summary of teaching strategies is presented. (YP)

TEACHING STATISTICS TO THE NONSTATISTICIAN PART-TIME STUDENT: ISSUES FOR CONSIDERATION

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The literature on statistical instruction may be broadly divided into three categories. The first relates to articles about ways of teaching specific statistical concepts (e.g., Cobb, 1984; Faulkenberry and Tortora, 1979; Smith and Iglewicz, 1982; and Whitmore, 1986). These articles are intended to facilitate instruction in any statistics course where the concepts are taught. There is usually no discussion of the audience receiving the content, nor of the relevancy of the content to any particular field.

The second category of articles deals with general pedagogical strategies that may apply to good teaching in any field, but are specifically directed to statistics instruction. While these articles may not directly address specific topics, they are typically aimed at better strategies for an entire course. They rarely, if ever, address any differences among recipients of the instruction. These articles range from explicating a specific strategy, such as the use of lecture notes (Beus and Hardy, 1987) and real data sets (Singer and Willett, 1988) to advocating general strategies or techniques, such as grounding a course in problems, questions, and data (Kempthorne, 1980) or using three to six "key points" for each lesson, followed by written feedback from students as to their specific questions and concerns for use in subsequent lessons (Mosteller, 1988).

The third category of articles generally deals with service courses in applied areas, and address specific statistical needs of the audience in those areas. The fact that an introductory statistics course is required in most graduate programs is not argued here. However, what should constitute the

goals and/or content for such courses is being debated in various disciplines. Hence, the focus on curriculum and what should or should not be taught rather than how it should be taught. For example, for statistics courses directed at graduate business majors, one request is for greater emphasis on data analysis and modelling techniques rather than the mechanics of significance testing (Rose, Machak, and Spivey, 1988; Roberts, 1987). Another request is to "reduce emphasis on formal theory of statistics and probability and to increase emphasis on intuitive concepts and applications" (Easton, Roberts, and Tiao, 1988, p. 248).

Often these articles also deal with specific student characteristics in service courses, such as "minimal mathematical background and considerable fear of anything with the slightest quantitative flavor" (Blalock, 1987, p.164), and the need to assist students in an attitude change and in overcoming the difficulties of a subject that all too often presents them with a "foreign way of thinking" (Evans, 1986, p.28).

The focus here stems from a client perspective, where the student is generally viewed as a client who will eventually be in a given profession and have specific statistical requirements within that profession. A general consensus across disciplines is that an introductory statistics course for non-statisticians needs to be focused on applications relevant to students' substantive field and that the accomplishment of this objective should be done through the use of real data sets and real life problems.

What is generally missing in the expanse of statistical education literature is an appreciation of a growing body of already established professionals who

are only part-time students. One paper that addressed the idiosyncratic problems and requirements for effectively teaching service courses to such students (Belli and Seaver, 1989) did so in an attempt to delineate the differences in student profiles (i.e., older, part-time students, often with limited mathematical and computer knowledge, but with very explicit requirements for applied statistical skills and with high intrinsic motivation) and time factors (i.e., available study time, out-of-class interaction time, a typical schedule of three-hour evening classes once a week, and family and job commitments) in order to provide general guidelines for addressing these factors, particularly when the courses are in off-campus settings. If not addressed, these factors can impact on both quality of the instruction and learning.

The present paper extends the discussion of problems and general solutions by summarizing some specific strategies that have been effective with part-time students in off-campus settings. Although most of the suggestions may be found elsewhere as simply good teaching strategies in any environment, their incorporation into a unified pre-planned system is crucial to overcome the difficulties in part-time programs in order to provide a course comparable to what a full-time on-campus student receives.

The approach taken is to initially focus on three problem areas: (1) the need for realistic applications of more than simplistic statistical techniques, (2) teaching statistical thinking to students with diverse, and often limited, mathematical and computer background, and (3) supplementing inadequate introductory statistics textbooks in applied areas. The following discussion outlines a few problems and partial solutions that show how these three

concerns can be addressed through common solutions. Although the discussion may apply to any graduate level applied statistics course, the problems are particularly troublesome in part-time, evening courses that consist almost entirely of working professionals. This class composition, however, also provides an opportunity to tailor the course to the specific audience by incorporating students' work experience.

Selected Problems and Solutions

Realistic Applications

The recurring request from many disciplines is that introductory statistics courses need to use realistic applications and real data sets to teach the statistical content. If no "hands on" computer analysis is required, this can be accomplished through judicious use of published research articles in areas of interest to students, as well as through discussions of student generated research problems from their work experience. Given a similar class composition from term to term, the former can be readily done with a one-time major effort to organize a good, relevant set of articles and only minor additions/revisions in subsequent terms. One useful option for the revision process is to give students at least one assignment to find and critique a recent article published in their field that deals with one of the statistical topics discussed. This provides the instructor with new material and the student with an application of interest. The effort required by each student is minimal, in recognition of their time constraints, but class discussion of different articles

provides greater breadth of coverage with respect to various realistic problems and statistical applications.

The latter possibility of using problems from student work experience certainly can add greater interest to a class, but requires greater flexibility and creativity on the part of the instructor to integrate the new problems into an existing course framework.

Computer Skills. When student generated analysis is required, the obvious advantages of providing interest and motivation through realistic problems has to be balanced against student computer skills. A well-thought out, real data analysis problem loses its utility if the primary student concern is focused on the mechanical aspects of output production.

We have found, in 10 to 15 week terms, that if the introductory statistics course must include extensive computer instruction the initial use of small data sets frequently found in textbooks actually work best. This is particularly useful when the text also provides sample outputs and detailed discussions of analyses and final results. This is also essential when students have no framework for thinking about data layout and the distinctions between variables and cases. The problems some students in one class had in recognizing this basic distinction became evident when they were forced to input data for a 2x3 ANOVA design consisting of three scores per cell. Although previous test performance had indicated an "understanding" of factorial design and the distinctions between dependent and independent variables, their misconceptions did not become evident until after they struggled with this exercise. This struggle also helped to clarify their thinking.

Some students can move quickly from small data sets to larger and more interesting data sets and analyses, however others need extensive practice on relatively simple exercises. To efficiently enhance necessary computer skills while maintaining an effective and uncompromised coverage of the statistical content is a difficult task. Providing videotapes of computer short-courses on operating systems, on job control language, and on software applications that students may use and review at their own pace can facilitate the task. This requires extensive advance preparation, appropriate equipment, plus student time to utilize the products.

A less equipment dependent strategy involves preparing very detailed, step-by-step, instructional materials that guide a student through the mechanics of working with their computer package or program. Although less satisfying, the latter have been effectively used by many of our part-time students because it frees them from having to come to the instructional site. Another option would include 30-minute demonstrations or show-and-tell labs before or after class for a few weeks to ease the computer phobias and to build the confidence of the student. This option, however, is sometimes difficult to implement when student schedules preclude finding a convenient and common time for such labs.

Student Projects. Giving students an opportunity to work on projects is another useful strategy to accomplish worthwhile goals and simultaneously alleviate some problems. Working professionals can typically provide not only work related research problems but also real data sets. If only a few students in a class can do so, teams can be created around common interests in the

available data.

Such work provides desired realism, stimulates thinking about creative analytic solutions, and gives students the opportunity to help each other in their learning. Groups can be judiciously formed so that inexperienced computer users are paired with "experts." In addition, Roberts (1987) found that student projects were excellent sources of data for future teaching illustrations. More importantly, the work done with students on these projects "sensitizes an instructor to the statistical ideas that require greater emphasis in teaching" (p. 272).

Statistical Thinking

A desired goal of service statistics courses is to teach statistical thinking. Such thinking is second nature to instructors of these courses who were typically trained in a mathematical/scientific mode. Students for many disciplines come to a service statistics course with predominantly a qualitative background. Beyond the obvious difficulties of not having specific algebraic or mathematical prerequisite knowledge, they think differently. A beautiful algebraic derivation that should provide an understanding of some statistical principle leaves these people cold. Not only do they not appreciate its meaning, but the underlying statistical concept and statistical way of thinking get lost.

If some algebraic derivation is used, such as linear combinations of random variables to communicate sampling distributions, then the meaning and interpretation of the results along with simulation runs and/or an illustration from a finite population where the sampling distributions for several statistics are

enumerated can greatly facilitate understanding of this difficult topic. The use of various modes of presentation for one topic is useful in reaching diverse math levels in one class. The main focus, however, should be on using such varied presentations to assist students in recognizing the reasoning behind the statistical manipulations.

Another solution for overcoming background deficiencies might be to introduce new topics with a basic review of the required mathematics or algebra properties and to "water down" the statistics so that it can be understood by all students. Such a solution is sometimes advocated by students. An unfortunate result of this approach is that one rarely, if ever, can then proceed beyond simplistic statistical techniques in a single course. In addition, this generally does little to develop a statistical thinking process within students.

A better approach might be to recognize that we are not training true statisticians, but attempting to provide practitioners with enough understanding of appropriate statistical tools so that they may better understand their own literature, be critical of problems in that literature, and when necessary, interact with statisticians in conducting their own research. This perspective ties in nicely with practitioners' need for realistic applications to problems that usually require more sophisticated techniques and can be accomplished through the use of real data sets that are being demanded by many disciplines. Implementation of this is very effective when computer skills are required and current, but complicated when students have minimal computer experience. The previously mentioned group projects can provide the necessary assistance here, plus be used to help students develop a statistical way of thinking about

problems, solutions, and analyses.

Textbook Concerns

Another typical problem we have encountered relates to the statistics textbook and its use. None is perfectly adequate in all topics and outside sources are needed to provide better coverage or different perspectives. There seems to be a wide range in how professional students deal with outside sources. On one extreme is the student who supplements the textbook with up to four other comparable texts in order to get a better understanding of course material. We have often recommended this as particularly useful for students who have limited opportunity to interact with faculty and students outside of class. At the other extreme is the student who gets totally confused by any attempt to use a different author's presentation of material. Therefore, a blanket suggestion of supplementary material has sometimes backfired. The problem is to find ways to differentiate between the two types of students and to find ways of assisting the student who has difficulty understanding different authors' notation and presentations.

Lecture Notes. Beus and Hardy's (1987) excellent argument for providing students with a complete set of "Lecture Notes" at the onset of a course addresses the lack of out-of-class time needed to organize lecture and textbook materials in a meaningful manner. According to them, these should consist of two basic components: (1) prewritten "textual materials" make up of definitions, theorems, drawings, statements of problems and/or examples, and (2) "learning materials," which are applications, completions of drawings, solutions to problems, and concept development recorded in class by the

student. These materials can be used to provide structure to the content, to emphasize important topics and relationships across topics, and to clarify notational differences across textbooks.

Practice has shown us, however, that one needs great care in constructing such materials so that they adequately allow for student input. Although one main purpose of the Lecture Notes is to relieve students from copious note taking and tedious detail, thus freeing them to listen and learn, it does not eliminate the need for time to interact with the concepts and problems or to flush out comprehensive outlines for themselves. Students who think they understand a presentation are often incapable of reproducing the concepts. The simple act of having to furnish their own words for a definition or procedure can assist the learning process.

Student Study Groups. Our experience has shown that many of the students we describe are often so confused at the beginning of the introductory statistics course that they are unable to phrase appropriate questions. One strategy used by some of our students was to meet weekly and arrive at a consensus of what a lecture or a textbook section meant and identify specific problems and questions. Then, one member of the group met with the instructor for clarification and reported back to the group.

Before proceeding with the advantages of such a strategy, it is important to point out that its success may be related to the discipline and mathematical level of students in an introductory statistics class. Our students from adult education and business, whose other courses often required group projects or interactions outside of class, were more receptive to study groups. In contrast,

engineering students typically had less need or propensity to work in groups.

Where needed, group work can be an effective learning aid useful in reducing some of the problems outlined previously. Students who have been involved in productive study groups report the benefits gained through the opportunity to discuss and compare ideas in an informal, relaxed atmosphere and with greater specificity than possible in a class setting. They helped each other clarify misconceptions though joint efforts at providing different interpretations than those presented in class or in the textbook. Each student also gained in his or her own understanding by being forced to explain a concept to others. In addition, they were able to share and learn from others' experiences with research. This provided real life problems that they could relate to their classroom learning.

In one group, students took turns being responsible to learn one topic well enough to teach it to the group. The result for the "teacher" was a thorough learning of one topic that enabled relating new information from topics other students "taught" into their own framework. Typical comments from individual students who tried this solution included a recognition of the "value of group struggle," that the group process was "the panacea for many of us," and that "only in this way were we able to pass the course."

A side benefit for many students was derived from the comfort in knowing that others shared their frustrations, problems, and phobias about computers and statistics. Although not a tangible result, students reported that this knowledge helped them to gain perspective, to keep calm enough to be productive learners, and to gain confidence in their ability to perform.

Several students suggested that instructors make such group work mandatory and incorporate it formally in class presentations. The former request is probably not realistic or desirable. Some students physically cannot become involved in study groups because of distance or time constraints. A very few find group work more confusing than helpful and prefer to puzzle out problems on their own. However, the instructor could outline the benefits of group work in the first class session and strongly recommend that students consider study groups.

The latter suggestion can be facilitated by the instructor by calling on group members (or individual students who elect to work alone) to present their specific questions, and potentially, their solutions to these questions as well. This method could be formally included in the first 20 or 30 minutes of each class, thereby giving the instructor feedback on what aspects of prior lessons need to be reinforced. Students would feel a greater sense of involvement in the lessons and could assist in the reinforcement of content by providing alternative explanations or real life examples to demonstrate a research problem or analysis strategy.

Student Perspectives

An informal poll of part-time students who have taken an introductory statistics course supplied the following requests to instructors in this setting: be understanding of students' time constraints, be sensitive to their phobias and ignorance of computers and math, recognize that students may not be there

willingly, and be patient. Such requests may be interpreted as a desire for simplified courses. Yet, these same students offered the following set of suggestions to other professionals entering a statistics course. First, in recognition of the typical lack of background, they suggested that students take a very elementary mathematics or statistics course before the required graduate level statistics course, and become familiar with computers before entering the course, either on their own or through a short course. Second, with respect to planning, they encouraged students to not take another demanding course in the same term, and plan to reorganize their lives to allow for the needed study time. Third, during the course itself, they stressed that students should be prepared to work hard, and to do whatever it takes to enable them to meet out-of-class with a study group.

These are not recommendations that would suggest a desire for a way out. Unfortunately, the first set of recommendations about prerequisites are seen as valid by students only after they are already in a statistics course. Unless there is a requirement for specific prerequisite course work or demonstrable computer skills, working professionals with limited time for school generally opt out of acquiring the background and skills because they perceive this as "wasted time." There are always examples around of students who also lacked the background, yet made it successfully through the statistics course to reinforce this belief.

It is because of this reality that instructors need to create an environment that utilizes student input and interactions with each other in ways that provide the real life aspects and that use stronger students to assist weaker ones to the

greater benefit of both.

Summary of Useful Strategies

The following list is provided from a synthesis of existing literature on teaching techniques, our own experience, and student opinion data from a non-random sample of part-time students in service statistics courses. No attempt is made here to rank order these suggestions in terms of importance. Our hope is to foster a discussion that will lead to broader consideration of the needs and problems in teaching part-time students and that, hopefully, will provide additional useful and viable solutions.

A. Regarding Materials and Other Aids:

- Provide complete set of "lecture notes" at beginning of course (i.e., copies of handouts, overhead transparencies with spaces for additional note taking).
- Select a well written textbook that can be used as independently as possible so that students with limited possibilities for interaction with faculty or other students can adequately progress in their understanding of course content. If possible, the text should include a good glossary, a variety of problems and exercises, and detailed computer analyses.
- Make available videotapes of classroom presentations and of computer short-courses on operating systems, job control language, and software use.
- Provide detailed answers to selected homework problems either as handouts or on computer files that include the run streams and annotated outputs

of computer analyses.

B. Regarding Out-of-Class Assistance:

- Provide a statistics lab for assistance during evening and weekend time periods.
- Provide a computer lab for teaching and reviewing computer analyses.
- Be available for individualized assistance.
- Encourage study groups. Provide a brief training session on how to use them to maximize use of limited student-teacher interaction time and reduce elements of fear and initial confusion.

C. Regarding Classroom Presentations:

- Plan for and incorporate preliminary previews of mathematical or algebraic prerequisites to further assist students.
- Discuss research articles that illustrate principles being taught.
- Maintain a relatively slow pace.
- Use classroom interaction to solicit real-life research problems and examples from students' work experience.
- Work problems in class.
- Give explicit instructions.
- Be flexible.
- Use humor to help students relax.
- Keep the class interesting.

D. Regarding Student Background:

- Use a diagnostic pre-test keyed to reference materials to assist students with rusty or non-existent prerequisite mathematical skills to identify

deficiencies and have a means of correcting them.

- Use a student survey at the beginning of the course to determine present job responsibilities, future career goals, and student access to work related data to assist in selecting relevant data sets with realistic applications.

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