SESSION VIII ON-LINE COMPUTERS IN TEACHING PSYCHOLOGY: II. TEACHING STATISTICS AND EXPERIMENTAL DESIGN

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What simulation can do to the statistics and design course

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The increasing appearance of an integrated statistics and research design course is noted, and the use of computer simulation in such a course is discussed. Four different kinds of courses are suggested: the problem set course, the demonstration labs course, the design-your-own course, and the "research community" course. Example simulations are discussed for each course.

The undergraduate course in statistics and research methods has changed over the years. The instructor need only look at the books that are being published for these courses—*Experimental Psychology* (Kantowitz & Roediger, 1978), *Experimenting in Psychology* (Gottsdanker, 1978), *Behavioral Research: A Conceptual Approach* (Kerlinger, 1979), and so forth. Years ago, statistics and experimental psychology were separate courses. In the last 5-10 years, the move has been toward an integrated course where the essentials of research design and experimental method are taught along with the statistics. The old self-contained statistics courses still exist, but the new wave certainly is toward an integrated course.

In this session I will attempt to illustrate different ways of packaging the statistical and design materials into a single integrated course. The course will be structured as a typical three- or four-unit undergraduate course with several hours a week of lecture and perhaps an accompanying lab session once a week. Of the four different approaches that I'm going to suggest, only one requires a lab. It, too, can be conducted without a lab session by doing the lab experiments during regular class time. The four different kinds of courses are the "problem set" approach (a very traditional course), a "demonstration labs" course (this is the variety that would probably work best with a separate lab session), a "design-your-own-experiments" course, and a "research community" approach. I will refer to various computer simulation programs that can be used to support the

courses. Some of these programs are discussed in other papers in this issue.

THE PROBLEM SET COURSE

Any self-respecting statistics course must confront the students with a variety of problems both to provide computational drill and for practice in presenting statistical results. The traditional statistics course proceeds with lecture material and homework assignments, interspersed periodically with a more major exercise called "the problem set." A problem set consists of a range of exercises that the student is to complete. An important goal is to obtain correct numeric answers. Many courses and instructors have this as their primary aim. In other cases, students may be required not only to carry out the calculations, but also to practice the APA publication style by writing a results and, perhaps, discussion section, complete with appropriate figures, tables, and, references.

The traditional problem set has been such a stalwart member of the teaching tools of a statistics professor that it is not likely to be dropped entirely from the repertoire. But it has certain difficulties. Traditionally, a problem set consists of a series of problems with data. The data are typically the same for all members of the class. This makes it easy for the instructor, who must work out the answers only once. At the same time, it also makes it easy for the students to work on the problems in a cooperative fashion, thereby perhaps

doing only part or, in the extreme case, none of the arithmetic themselves.

For several years now, I have been using problem sets in my teaching, but generating the data for each problem by computer. I have written a set of data-generator programs that handle the common kinds of experimental designs (Lehman, 1978). These programs allow me to input appropriate population parameters, descriptive labels, and so forth, for each group of data. They generate random sets of data, and for each, they also calculate and print a fairly complete instructor's record.

Using data generators, the traditional problem set can be used, but each student is given a unique set of data. Clearly, this cuts down on the sharing of answers across students because all data sets are different. The presence of the instructor's record simplifies grading because the instructor need not compute any of the correct answers, let alone one for each different set of data.

When I started using this approach, I discovered a fringe benefit that I hadn't anticipated. The students are still working cooperatively, but now they often calculate their own, and a friend's, answers. It provides a cross-check for them as well as increasing the amount of calculational practice they obtain.

I also encourage the students to check their scratch copies of the calculations against the instructor's records that I maintain in my office. This has headed off major calculational difficulties and allows me a chance to discuss the problems with them, hopefully setting them straight before they commit their answers to the final report. It also lets me focus my grading attention on content and format, rather than on the details of arithmetic.

My programs aren't the only ones to use; any convenient source of random numbers, scaled properly, will suffice. In addition, many of the content-area simulation programs lend themselves to the production of data. It is conceivable that one or more problems in a problem set would require that the students go off to some packaged computer program, run a simulated "experiment," and analyze the data. Unless the program is fairly sophisticated, this option doesn't provide an instructor's record.

THE DEMONSTRATION LABS COURSE

A course in statistics and design that has a laboratory session is probably already a demonstration labs course. Each week or two, the lab session is devoted to generating some data; perhaps some of the experiments are simulated, and others are easily runnable, short, in-lab demonstrations. There are a couple of nice features to this approach: One of them is getting students involved with generating their own data, whether it be by actual experiment or by simulation. The more involved the students get with the conduct of the research that's involved in a statistics and design course, the more

meaningful it is to them and, I suspect, the more they learn.

Additional benefits include the ability to sample a range of phenomena, equipment, and experimental paradigms. The lab course can be coupled with textbook and lecture material that goes through a sampling of representative research areas. The demonstration lab can illustrate not only how to obtain, deal with, summarize, describe, and report statistical data, but also the concept of a good experiment. In a single lab session, it's quite possible to illustrate a simple one-group experiment, or two independent groups, or repeated measurements, and so forth.

Good examples of the kinds of one-shot lab experiments that could be used for this kind of course can be found in the instructor's manuals or student workbooks of several of the new experimental design/experimental psychology/statistics textbooks. Some of the programs discussed in this symposium might be appropriate. I suspect that LABSIM (Eamon, 1980) and the cognitive psychology package from Levy, Fischler, and Griggs (Note 1) are more appropriate for individual or small-group efforts on a take-home assignment basis.

THE DESIGN-YOUR-OWN-EXPERIMENT COURSE

In many of the new statistics/research design courses, students are required to develop a research proposal. Often the assignment takes the form of a library research paper, culminating in a statement of hypotheses and perhaps a sketch of a methods section. A simple additional step is to use some simulation program to generate the data for proposed experiments, which can be returned to students who must complete the analysis and write-up.

One of the courses that I teach regularly fits into this model. It's a second-level statistics course, and students are required to propose a study by writing the introduction and methods sections of a report. I generate data and give it back to them. They must analyze the data and complete the results and discussion sections. Using general-purpose data-generator programs, the instructor need place no particular constraints on the subject matter or, indeed, the design itself of any experiment. For pedagogical purposes, of course, the instructor will usually specify a two-independent-groups design, or a one-way analysis of variance with no repeated measures, or something of the sort.

Any of the variety of small simulation packages can be used in a design-your-own course. The assignment would have to be a bit more constrained to fit within the restrictions imposed by a particular program; for example, in order to make use of the software from the University of Florida On-Line Lab or the memory and cognition programs discussed by Keenen and Keller (1980), the instructor would have to provide some background in the appropriate cognitive psychology content areas. That done, a selection of possible research topics

could be presented to the students. The data could be either collected by the students or generated by the instructor.

The EXPERSIM system developed by Main and Stout (Note 2) at Michigan provides another, in this case, very large computer system that can be used for a design-your-own-experiments approach. EXPERSIM is a large FORTRAN program that embodies several well-developed and well-documented experimental modules. Two modules—one for imprinting (Rajecki, Note 3) and one for schizophrenia (Malin, Note 4)—are distributed by CONDUIT. With a little background presentation by the instructor, or by reading the supplied manuals, students can develop experiments in any of the content areas represented in EXPERSIM. Once the experiments are proposed, the students can proceed to generate their own data, or have it developed by the instructors, and complete the analysis.

THE RESEARCH COMMUNITY COURSE

An outgrowth of a design-your-own-experiments course, could involve the "publication" of student-conducted research. This way of conducting a course was first suggested, to the best of my knowledge, by Dana Main in the context of EXPERSIM, and I'll describe it by using an EXPERSIM example.

Students can be led through some introductory material in some content area—for example, imprinting. Then, using the EXPERSIM imprinting model, they collect data and analyze their own studies. If these experimental studies are distributed to other members of the class, we have a simulation of an ongoing research community where additional studies can be built on the published results of previous investigations.

There is no reason, of course, why this develop-conduct-publish sequence need be limited to only those subject areas covered by EXPERSIM. Any of the simulation programs discussed here or those distributed by CONDUIT (which includes not only EXPERSIM but also Bewley's, Note 5, almost classic cognitive psychology package) could serve equally well in the course where students develop and publish studies on their own.

The simulation of a full research community can be an exciting and intriguing introduction to the world of behavioral research for our students. There are some limitations, clearly; one is that it can be very time-consuming and is perhaps best limited to very small and informal class settings. The second potential limitation is the availability of simulation material in subject areas that are of interest to an instructor. With the exception of EXPERSIM, nearly all available program materials are designed for a particular subject area, most often cognitive psychology. EXPERSIM offers, in its CONDUIT-distributed version, imprinting and schizophrenia. Other EXPERSIM models are available with supporting materials. In addition, the main program for EXPERSIM and a model developer's handbook are available through CONDUIT (Main & Stout, Note 2). Using this material,

the instructor can develop simulations in new areas. Finally, although it is probably not the optimal solution to the problem, the instructor can use any of the random number generating procedures, including my own, to provide data for simulated experiments, which could then be published.

CONCLUSION

When John Castellan called and asked if I would take part in this symposium, my first response was to say that I've said all this before (Lehman, 1978; Lehman, Starr, & Young, 1975). Indeed, I think I have said most of what I have just said at various other times and places. I've not intended here to shake up the world, propose any radically new ideas, or even to break any new ground. What I have tried to do is to pull together, under the rubric of four different kinds of packaging for a stat and design course, some of the material that I'm aware of, and that we're talking about today. Perhaps you'll be able to conceive of ways to include the material from the previous session of this symposium, and some of the ideas of my colleagues on this panel, along with some of my ideas, into your own courses in statistics and design. If it has had any impact on any of you, made you think about your course, or prompted you to offer disagreements or new ideas, then I'm glad that I have said the same things again.

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