SESSION 1

PRESIDENTIAL ADDRESS

Microcomputers in undergraduate laboratory training in psychology

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Goals for undergraduate training in psychology are reviewed, and a survey is reported to suggest ways in which computers are being used to meet these goals. Currently computers primarily aid data collection and analysis. Computer-based literature searching and word processing are becoming more common. The true challenge of laboratory training, however, is inquiry training: helping students generate and frame research questions and interpret their results. Are we using the time we have gained through computer data collection and analysis to meet these goals? Are there ways in which the computer can directly help us meet these goals? The new generation of flexible experiment-generator software may provide direct help of this sort, as may effective simulations of theory.

My hope is to stimulate discussion of the laboratory training provided to undergraduate psychology majors and to consider what microcomputers have to offer for this activity. I will not review particular software or hardware. Instead, I wish to determine what roles computers now play and whether that use is optimal. I will try to challenge laboratory instructors to use these teaching resources more effectively. Such an evaluation is part of a revitalization we currently seek for a laboratory course we require of all psychology majors at the University of North Carolina at Chapel Hill. We have utilized microcomputers for over a decade in this course, and we now serve over 300 students a year. We are, however, about to retire our decade-old system and introduce a new hardware/software "platform." The present review is part of our effort to decide how we might best jump from this platform.

I have a great appreciation for the way I was introduced to the psychology laboratory. I was a student at a small, liberal arts college (Hamilton College). Our year-long introductory psychology course included a 3-h/week laboratory. The course was taught by Professors Godcharles, Stebbins, and Geis from the clear perspective provided by an "experimental analysis of behavior." For those who do not identify this phrase, it means that the course was

thoroughly "Skinnerian." Our emphasis was on the theory of behavior—especially on an operant analysis of behavior based on learning processes that could be reliably demonstrated for individual subjects. The laboratory was similar to one developed by Keller and Schoenfeld at Columbia University—a laboratory course that provided the "hands-on" introduction to psychology for many currently eminent psychologists.

Our main theme was straightforward. In September we got our rat, and in May we all were better educated. Exercises that involved the rat were intermixed with exercises for which we were our own subjects—we tried out psychophysical methods, studied aspects of verbal learning and verbal behavior, and even carried out some psychological testing. Regardless of our topic, however, in each week we completed an exercise and in most weeks we wrote a lab report. By May, we had written well over 15 reports and were well versed in how to summarize, characterize, and interpret the kinds of data that we had obtained. By May, we were well on the way to becoming researchers. In fact, of the 10 psychology majors in my graduating class, 7 of us earned the Ph.D. in experimental psychology. Something must have been working well in this introduction.

Our experience was effective in several ways. It made past work concrete; it confirmed to us that basic facts of psychology were true in our hands; it shocked us into realizing that results were always different in detail from the "idealized curves" provided by summaries and sec-

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ondary sources; it forced us to fit our observations within the larger framework of the theory of behavior; and it challenged us to turn our vague worries and intuitions into questions that could be studied. During this process, we learned to value data, learned the importance of clear data summary and display, learned to characterize what data show without overinterpretation, learned to generate researchable questions, learned that there is more to discover, and learned that we were already doing it. While we studied prior work, in each case we were encouraged to "build on" this prior work rather than merely remember or honor it.

I think that Posner and Osgood's description of goals for inquiry training (1980) comes close to the experience that we received. Their description jumps us a few steps by addressing computer-aided instruction directly:

Our desire is for a computer facility that allows the beginning psychology student who never before has touched a computer terminal to conduct meaningful inquiry into important and interesting psychological topics that will eventually in the kind of experimental results that could be communicated at a meeting of a professional society. . . . The design of university education implies an image of the human. We believe that an image of a mainly passive learner, absorbing material in order to eventually be fit into a proper position in the societal hierarchy will not do for the future of universities and is also inappropriate to ideas emerging from psychological research. The proper goal for education is to produce an environment that will foster the inquiring mind. (Posner & Osgood, 1980, pp. 88-94)

When I arrived at the University of North Carolina in Chapel Hill in 1966, I discovered that psychology was considered a natural science there. John F. Dashiell had established the introductory psychology course as an option toward meeting the natural science requirement many

years ago, and laboratory work was included. The spirit of our introductory course thus had something in common with the one I had experienced. UNC was, however, not a small college. In 1966, we taught a total of 1,300 students in introductory psychology. Large lecture sections were taught by faculty. These lectures were supplemented by small lab sections that met once each week, which were taught by graduate teaching assistants (TAs). Our topics were eclectic, and so were the laboratory exercises, with topics ranging from psychophysics to personality assessment. We primarily used demonstrations, with our equipment being dusted off each term.

We did a fair job with the introductory psychology laboratory. We were not prepared, however, for the avalanche of students that was coming. The university was growing steadily (see Figure 1), but the number of students desperate for a course in psychology was growing more rapidly by far. Within 4 years, we were teaching 3,000 students per year in the introductory course, and the laboratory sections had grown to 50 students each. Our faculty resources become so strained that we reluctantly eliminated our laboratory and converted graduate TAs to lecturers, giving each of them full responsibility for a section of the course with around 85 students. We stepped aside from our goal of active inquiry training.

Since that flood in the late 1960s, our introductory course has had a stable enrollment. Without increased teaching faculty, we have only been able to offer a limited number of sections. We have also taken our laboratory training to a different audience—our psychology majors. Our "main job" as an undergraduate faculty, of course, is to train our majors. This was another job that became more difficult in the late 1960s and early 1970s. The astronomical rise in the number of psychology majors that we experienced from 1966 to 1973 is documented in Fig-

Figure 1. Numbers of psychology majors and students in introductory psychology and the psychology laboratory course, compared to the numbers of juniors and seniors at the university from 1960 to 1990. Note that values for juniors and seniors and for introductory psychology students are 10 times those shown.

ure 1. Our faculty grew in number, but only modestly, and resources were far outstripped. I fear that we again temporarily compromised our ideals. There was considerable relief, then, when we witnessed a decline in the number of majors from 1974 to 1981. In the context of this relief, a new plan for laboratory training emerged.

Before describing this plan, however, I would like to place our experience within a larger context. Our experience during the 1970s must have been duplicated around the country. In a recent article, Turner and Bowen (1990) have documented the gradual increase and then decrease in the "market share" of undergraduates who selected psychology as a major during this period. This more dampened national picture (see Figure 2) has undoubtedly resulted from an average of many individual experiences similar to the one we have had at UNC—that is, larger but asynchronous fluctuations (e.g., compare the patterns shown in Figure 2).

Sometime after 1976, we recovered our composure sufficiently to start planning to teach a general laboratory course once again. This time, however, we set our goals a bit more modestly. We decided to teach the course only to majors. A single one-semester lab course was proposed to follow our one-semester course in psychological statistics. This course would be pitched to juniors, in the hope that many would utilize the experience they were given in independent study during their senior year. Topics in the course would range from "cells to society," just as in academic psychology. Students could thereby "find themselves" and identify their particular areas of interest from the course material. Sections would be small, and the syllabus would be designed so that relatively inexpe-

rienced TAs could teach the course well. We decided to utilize the emerging microcomputer as much as possible and thereby avoid dust-gathering specialized equipment.

The plan was put in motion in 1979 when we squeezed an Apple II out of our budget and capitalized on the generosity of a CAUSE grant in another department to obtain a copy of the Laboratory in Cognition and Perception (Conduit, University of Iowa). We tried out this "core" for our new course with a few hearty, adventurous students in the spring of 1980. We wrote and received an NSF award (with UNC matching funds) that allowed the purchase of eight Apple II+ computers networked to a 20-MB Corvus hard drive. By 1985, graduating psychology majors were required to take the course. Our course has evolved since that time. With considerable help from Richard A. King, Marcus B. Waller, and many graduate TAs, we are continuing to develop a syllabus that mixes computer and noncomputer exercises and requires much writing. I am pleased to report that we now seem better prepared to defend the quality of our teaching against the throngs of psychology majors that we have witnessed since 1981 (see Figure 2). We now teach about 350 students per year, in a total of 28 laboratory sections that contain around a dozen students each.

The software that we use in our course is listed in Figure 3, separated into the four kinds indicated by Hewett (1986). Simulations and tutorials are used in two class meetings to provide demonstrations that promote discussion. One such demonstration provides practice for students preparing to shape a rat to press a lever (Catania's Shaping Simulation). Another class session on physiological psychology involves simulations derived from John

Figure 2. Proportion of juniors and seniors in the College of Arts and Sciences at the University of North Carolina who designated psychology as their major, compared to the proportion of arts and sciences bachelor's degrees that were awarded to psychology majors for the period following 1960.

Figure 3. Types of software utilized in the University of North Carolina laboratory course. The Shaping Simulation software is included in the Psychology on a Disk from CMS Software, Ellicott City, MD; the two programs attributed to John Hay are from PsychWorld, McGraw-Hill Book Co., New York, NY; the FIRM software is produced by Conduit, University of Iowa, Iowa City, IA. The two experiment-generator systems are also available from Conduit and have been described in this journal (see Keenan & Keller, 1980; see also Ransdell & Levy, 1989, for a current version of their software).

Hay's MicroWorld, to make brain localization and the split-brain syndrome concrete. In one of the sessions on social psychology, we utilize a "data generator" program (FIRM, Conduit, University of Iowa) that allows predictions to be derived from prior studies on the effects of crowding. Of course, we use analytic tools for some data management and statistical activities (e.g., calculating scores on personality tests). But our greatest use by far involves experiment-generator programs that allow students to carry out their own experiments (see Figure 3).

I hardly need to tell the astute reader, however, that our Apple II/Corvus network is now difficult to maintain. I shudder to think what would be involved were both the primary and the back-up hard disks to crash, or were we to encounter a difficult networking problem. Only old-

timers with good memories could help. In fact, at the time of this writing, funds had been found to buy 10 Macintosh IIsi computers. Funds for networking and appropriate software are still being sought, but we hope to have our new system in operation by September 1991.

Before this "revitalization" can proceed, we need to consider our goals for the course, and we need to generate student activities that meet these goals. Our shiny new computers should not determine these goals; they should help us meet them. Walker, Newcomb, and Hopkins (1987) offered us some guidance. They report the process leading to a revision of the psychology curriculum at the University of Richmond in the early 1980s. Their faculty decided to provide training to their majors in the categories of activities shown at the left in Figure 4: building a knowledge base, training methodological skills, training communication skills, and sponsoring independent work. The Richmond advice, however, was discovered too late to determine the survey that I report here. My thoughts about this topic about a year ago led to the seven kinds of activities shown on the right in Figure 4: discovering background information, generating research ideas, framing research questions, collecting data, analyzing data, interpreting data, and reporting research findings. These two lists line up fairly well, except that I omitted an important topic from my survey list: independent work. We have, in fact, increased the importance of students' generating a research proposal in our course. Once I discovered the Richmond list, I realized that our increasing emphasis on this research proposal represents our own push toward independent work.

Figure 4. Type of laboratory training activities included in the survey (right column). These are tied to the activities designated as part of the psychology curriculum by Walker, Newcomb, and Hopkins (1987).

A review of our current course suggests what activities we consider important. This review may help as we consider what our laboratory course is intended to train students in. I carried out an analysis of how much time we ask that students spend on various topics and activities. This analysis is shown in Figure 5. The abscissa arranges the various course topics in approximate chronological order. Our initial assignments require the students to summarize and evaluate two experimental reports: one that we hand out and another of their own choosing. These assignments do not involve very much time, but they do require that the students gain some background information, analyze experimental data, and practice their reporting skills. The stacked bar above "critical reviews" in Figure 4 shows the time that I believe they spend in these activities both in and out of class. From the left to the right in Figure 5, each stacked bar shows the estimated cumulative time in each of five groupings of activities (see legend). Topics are addressed through the use of approaches, including experiments (Exp), discussions (Disc), demonstrations (Demo), and the development of the student's own research proposal. By the end of the course, I estimate that students have spent a total of around 130 h (omitting time for "incidentals" and "daydreaming"). I take some pleasure in concluding that the writing of reports (two critiques, four APA-style reports, and a research grant proposal in NIH format) and the reading of course and proposal materials (background) absorb

most of these hours. Carrying out data analyses, puzzling through interpretations, and developing research ideas follow in turn. If my estimates are correct, our students spend relatively little time in the actual collection of data (around 12 h). This distribution of effort seems quite appropriate to me.

A Survey of Laboratory Courses

Though I took some pleasure in this sketch of our course, I was eager to learn how others arrange the distribution of effort in their laboratory courses. What guidance would others offer for our reconsideration of our course? Further, I was interested in discovering what role microcomputers are now playing in laboratory courses. How do others put these tools to work in meeting their educational objectives? I am grateful to the many people who responded to the survey I distributed in search of this guidance. During the spring and summer of 1990, laboratory course instructors were asked to review the activities they required and the role that computers played in these activities. I distributed surveys at conventions (Association for Behavior Analysis, American Psychological Association), mailed them to several individuals who had shown interest by responding to a "presurvey," and distributed them generally through bulletin board and email lists (with the kind help of M. Anderson and P. Hornby of COMPSYCH and S. Harnad of PSYCHOLOGY). In all, 75 surveys were returned. The return rate was highest

Figure 5. Estimated time spent by students in the University of North Carolina laboratory course in five types of activity. The sequence of projects in the course is in approximate chronological order along the abscissa. The stacked bars cumulate time spent in the various activities across the semester.

for direct mail (the expensive route), yielding 21 surveys for 57 requests. At the other extreme, handing out surveys at conventions was fairly unsuccessful, yielding 13 surveys for over 175 handouts "delivered." E-mail provided an interesting low-cost option. In all, 41 surveys were returned in response to the email invitation; but one should realize that I had to make only 2 email requests. Of these email responses, 13 were returned via surface mail, while 28 were returned via email.

Those who responded accounted for teaching done over a broad range of schools and types of courses. The schools ranged as follows: less than 1,000 (4), 1,000–2,000 (18), 2,000–10,000 (27), and > 10,000 undergraduate students (18). The courses ranged from those serving 10 to those serving over 1,000 students per year. The course sections ranged from 2–3 to over 100 students. Remarkably, however, I was able to merge across these considerable differences in schools and course sizes, since I found no notable differences for these factors. I did separately analyze, however, the few surveys that reported work in courses primarily focused on training in statistical methods, since my focus was on courses with laboratories. An additional distinction seemed worthwhile: Laboratory courses were divided into those that offered a general survey of topics from academic psychology (much as our course at UNC does) and those that offered a specific content focus (sensation/perception, cognition/learning, etc.).

What was the distribution of effort reported for the "activities" designated in my survey? Figure 6 provides an

analysis of that relation. The dashed horizontal line is included to indicate what percent effort would be found were effort equally divided among the six specified activities. Overall, instructors in laboratory courses indicate that more than this "even share" of effort is spent in developing background information for the topics covered and in collecting data. These activities take over 40% of their reported effort. Compared to instructors in specialty laboratories, general laboratory instructors reported spending quite a bit less time in developing background information for the topics that they addressed and reported spending a little less time in helping students generate and frame research ideas and analyze the data that they collected. They report spending a bit more of their time in collecting data. In both types of laboratory, less than this "even share" of the time is devoted to students' report writing.

Our course appears to differ from the general pattern. Our students spend more time in developing background material (primarily in the research proposal), more time in interpreting data and writing reports, and relatively less time in collecting the data. I must admit that I like our distribution somewhat more than that which I find in the other courses. Do others share this bias?

Those who responded to the survey also indicated what proportion of each of these activities is aided by computers—both microcomputers and minicomputers or mainframes. A simple picture emerges: Microcomputers are used to collect and analyze data and to write reports and very little else (see Figure 7). When minicomputers or

Figure 6. The relative effort spent in seven types of activity in laboratory course represented in the survey. General psychology laboratory courses (Gen Lab), specialty content area laboratories (courses such as cognitive psychology, sensation/perception, social psychology, etc., are specified as Spec Lab), and courses in statistics (Stats) are separately averaged and compared to the University of North Carolina general psychology laboratory course (UNC Lab).

mainframes were used, they were used primarily to analyze data. In all, 70 of the surveys indicated that microcomputers were used; 26 of the surveys indicated that minicomputers or mainframes were used. Since the survey highlighted a computer-use theme and was distributed to computer users, I will not be able to convince anyone that it accurately measures the overall prevalence of computer use in psychology laboratory courses. I would like to claim, however, that the survey informs us about the

types of uses to which microcomputers are put by those at the forefront of the field. These experts currently report very little use of computers in gaining background for or in generating, framing, or interpreting ideas—topics that seem most central to inquiry training.

The Future of Computers in Laboratory Training

Is the reported use of computers optimal? It is certainly helpful, but I suspect that the true power of computers

Figure 7. The degree to which microcomputers (upper panel) and mainframe or minicomputers (lower panel) are utilized in various types of activities in laboratory courses. Groupings of courses are the same as in Figure 6. The ordinate shows the percentage of that activity carried out with a computer of the indicated type.

in teaching is as yet unrealized, since computers are currently put to use in what I would judge to be less educationally critical activities. In Table 1, I have listed ways that microcomputers might be used to make instructors more effective or to allow students more say in their education. I like to think of these as ways of empowering instructors and students. Helping instructors be more effective, of course, helps students as well and thus empowers both. Yet some distinction seems worthwhile between tools that primarily help instructors and tools that primarily help students. My list emphasizes several of the uses documented in the survey, but it foreshadows other uses as well. I hope the list supports the challenges I would like to offer instructors and software developers.

I might first take a moment to celebrate our current uses of computers. I find no fault with them. Microcomputers are very good "experimenters," and at present they are most commonly used in laboratory courses for data collection. This seems appropriate. Good data has much to recommend it. In our course, for example, students typically get very stable and interpretable data—always with the individual differences that are central to psychological reality, but for the most part devoid of the kinds of omissions, misidentifications, and illegibilities that mar the work of most young experimenters as they are get-

ting oriented to empirical work. I do not hesitate in celebrating the computer as a data collector.

A second activity aided by computers is data analysis. Again, accurate calculation and clear display are to be celebrated. I am pleased that I no longer face the prospect of occasionally staring at an impossible negative sum of squares after entering calculations for half an hour. In our course, we gratefully use computers to carry out statistical analyses. I am concerned, however, that the computer may be capable of preventing students from having to understand and learn from their data. When analysis is too slick and easy, one can slip by, thus missing this understanding. It is our habit, in fact, to deliver the raw data to students at the end of one class period and ask them to bring preliminary analyses back for discussion in the next class period. They return with penciled sketches and calculator-based summaries that often reveal a struggle to grasp the questions being addressed. I would very much like to find computer-based approaches to guide this healthy struggle to "get familiar with" their own data. I am confident that spreadsheets and exploratory analyses will someday offer such guidance. The meeting of the Society for Computers in Psychology and the pages of *Behavior Research Methods, Instruments, & Computers* would seem to be excellent places to document these successes. But I have not yet discovered or heard very much about them, and I eagerly await such examples.

The above-normal use of computers in student report writing for our courses (Figures 5 and 7) results from our requirement that students prepare reports with a word processor. I would encourage all instructors to join us in requiring their students to use word processing. The impact of this requirement is uncanny. Students now actually *hear and consider* our helpful comments, which they once defensively resisted. Certainly the use of computers in writing activities will continue to increase. I doubt, however, that specialty psychology programs will be required.

The role of microcomputers as aids in developing background information will surely increase as well. Although only a few respondents indicated that they are currently using computer-based literature searching in their courses, I am sure that such a survey taken 2 years hence would demonstrate increased use of this resource. Computer-based searching of CD-ROM bibliographical databases has significantly changed our approach to helping students develop background for their research proposals, and I am sure we are not alone. Further, computer-based information resources in special content areas are also proliferating (e.g., neuroanatomical depictions) as developer-friendly "HyperCard"-varieties of authoring programs become more available.

My special wonder, however, is how computers can play a helpful role in guiding students as they generate and frame research questions and interpret their results. Such inquiry-training activities will surely never be automated; nor would "expert systems" seem that helpful. Yet computers can certainly play a helpful role. Here is where I would offer my challenges:

Table 1
What Microcomputers Can Do to Aid the Student or the Instructor

	Student	Instructor
Developing Background		
Demonstrate lit search		X
Carry out lit search	X	
Planning and Interpreting Studies		
Aid thinking about the topic (inquiry)		
Electronic chalkboard		X
Demonstrations		X
Simulations and "what if" scenarios		X
Thought experiments		X
Allow more topics to be covered		X
Allow new topics to be covered		
Instructor's interests		X
Student's interests	X	
Build on prior work	X	X
Collecting and Analyzing Data		
Provide new apparatus	X	X
Simplify apparatus	X	
Improve accuracy and efficiency	X	
Improve skills		
Lab skills (e.g., shaping)	X	
Analysis skills (e.g., use of SPSS)		X
Personalize data	X	
Allow merging data		X
Allow new analyses		X
Allow new data displays		X
Reporting Research		
Change impact of feedback		X
Make formatting easier	X	
Encourage rewrites	X	
Simplify making tables, figures	X	
Improve skill in typing	X	

1. At a minimum, a pleasant side effect of what has already been reviewed offers some help in this important category. By making other aspects of laboratory training more efficient, computers potentially make more time available for instructors to address these aspects of training. One challenge I would put to laboratory instructors, however, is to ask whether they are using their discovered time wisely. It is tempting to fill this time by adding another project. Yet I wonder if the time might be spent more wisely in inquiry training.

2. A second challenge I would like to make to laboratory instructors is to use the flexibility that computers allow. Experiment-generator programs increasingly allow instructors to select topics and approaches to experimental questions flexibly. The variety and sophistication of experiment-generator programs is increasingly rapidly. Inquiry training is improved when students can be involved in selecting topics, questions, and variables, as well as in experimental design. Have you provided them with this option? Might computers facilitate this empowerment? Furthermore, students appreciate "getting to know" their instructors by having instructors who bring their own research interests into the laboratory course. Have you opened your own chest of research questions and invited students to help clarify topics of personal interest?

3. A third challenge is to discover even more direct roles for computers as tools in promoting inquiry training. Spreadsheet simulations can aid small discussion groups to carry out "what if" thought experiments (see Hewett, 1985). Concrete but dynamic models can sharpen and extend concepts. I have seen this approach work for a group considering implications of learning theory. Rather

than passively watch a demonstration grind out prearranged procedures, participants can actively explore a theory and set their own paths and paces in this exploration.

Certainly not all computer programs currently available to enhance laboratory training in psychology have resulted from the efforts of members of our Society. Yet a remarkable number of these programs have been developed by our members and have been announced at our annual meeting. Our members have taken essentially all the awards given to developers of this software. My last challenge, then, is to those of you who are currently developing the next generation of software to improve our teaching of laboratory skills. I challenge you to foster inquiry training as well as to improve data collection and analysis.

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