DOCUMENT RESUME

ED 082 480 EM 011 442

AUTHOR	Osgood, Gilbert W.; And Others
TITLE	Computers in the Training of Experimental Inquiry in Psychology.
SPONS AGENCY	Department of Defense, Washington, D.C. Advanced Research Projects Agency.
PUB DATE	Jun 73
NOTE	7p.; Paper Presented at the Conference on Computers in the Undergraduate Curricula (4th, Claremont, California, June 18-20, 1973)
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Computer Assisted Instruction; *Computer Programs; *Experimental Psychology; *Experiments; Higher Education; Program Descriptions; Psychology; *Questioning Techniques; Research; Student Attitudes; Time Sharing; Undergraduate Study
IDENTIFIERS	Advanced Experimental Psychology; CAI; EW; *Experiment Writer; PDP 10 Computer; PDP 15 Computer

ABSTRACT

A program called Experiment Writer (EW) was designed to enable students to use the computer to sample a range of experimentation situations. EW was used by 20 students in an Advanced Experimental Psychology course; hardware consisted of a PDP-10 computer, and a PDP-15 computer with 12K of core memory and two time-shared stations. Experimental design using EW required three steps: 1) creation of files, 2) trial definition, and 3) block definition. Students performed two teacher-designed experiments to familiarize themselves with variability and the logical relation of experimental design to psychological questions. They next ran each other as subjects on a teacher-designed experiment and devised an experiment of their own dealing with information and reaction time. The third phase of the course taught them how to use EW, thus giving them full control over the computer. Following this, they designed an experiment creating files and block definitions. For the final exam they designed and ran experiments based upon a methodology presented in a paper. Evaluation indicated that EW successfully introduced students to experimental inquiry and showed that student reaction was favorable. (PB)

COMPUTERS IN THE TRAINING OF EXPERIMENTAL INQUIRY IN PSYCHOLOGY*

Gilbert W. Osgood
Cognitive Lab.
1695 East 17th St.
Eugene, Oregon 97403
(503) 686-4941

Michael I. Posner and Don Lycn
Department of Psychology
University of Oregon
Eugene, Oregon 97403
(503) 686-4939 and 686-4962

Training in experimental inquiry is a primary goal for every educational program in science. Yet very often traditional courses place so much emphasis on laboratory skills that they are better suited to training technicians than scientists. One solution to this problem has been to replace formal laboratory work with students serving as apprentices on faculty research projects. This has many advantages, but if introduced too soon it may lead to premature specialization in which a student is sophisticated only in one form of inquiry.

The ideal course seems to be one in which the student is introduced to a broad class of experimental situations, but in a format which makes possible observations which are not completely fixed in advance. This allows him to sample the excitement of an unforseen discovery or effect. Experimental psychology, which is full of the unpredicted, ought to be a fine vehicle for this kind of inquiry training. The computer provides a general purpose tool which allows the student to change variables at will and observe the consequences of those changes. The difficulty of computer controlled experiments in the past, has been the large amount of technical skill required to program the computer. Thus, it was often necessary to impose even more contraints on inquiry. We have solved this problem for a broad class of experiments by the development of a simple flexible program called Experiment Writer which can be mastered by the novice during a one quarter experimental course.

This paper concerns how we use the flexibility of Experiment Writer to teach experimental inquiry to undergraduate students. We first outline the general background of the course, including available equipment, characteristics of the students and general course format. Second we discuss the properties of the Experiment Writer program. Third, we present the detailed sequence of laboratory experiences provided the students. Finally, we provide a brief initial evaluation of the success of the course.

General Course Environment

The course is called Advanced Experimental Psychology and is a year long junior level course. It is not required but is recommended for serious majors interested in honors work and Graduate School. It has as prerequisite a year of introductory psychology and a quarter of statistics. The course is designed for 20 students, all of whom plan to spend the full year. Only the first quarter currently has a formal laboratory sequence. After that students are asked to develop individual projects to be run with the aid of faculty sponsors.

The course meets twice a week in two-hour sessions. No laboratory work is carried on in these sessions, but they serve to provide content material in Cognitive Psychology. The textbooks are Neisser's _Cognitive Psychology_ and Coltheart's _Readings in Cognitive Psychology_.

The computer facilities available for the course are as follows. The University has a time shared PDP-10 computer which is available for educational purposes and may be accessed from terminals located in the Computer Center or remotely from the Psychology Department. The Psychology Department has a PDP-15 computer which is used for research purposes during most of the daytime and many evening hours. The PDP-15 computer has 12K of core memory and operates two time shared stations. Each station has available an oscilloscope display, 10 bits of keyboard response, and 4K of core memory.

The computer facility is made available 4 evenings a week for 3 hours per evening. Using both stations 24 potential hours allows our ten teams each at least 2 hours of computer time per week to conduct their experiments. We hope eventually to be able to dedicate one time sharing station entirely to this purpose, making the computer available on demand at least 40 hours per week.

Experiment Writer

The Experiment Writer program is run on a PDP-15 Computer with 12K of memory and a DEC tape operating system. A time sharing system which currently operates two experimental stations has been implemented. An experimental station consists of an oscilloscope for the presentation of stimuli and ten keys for subject responses. A bank of twelve computer operated switches is also available for turning on and off tones, lights, inline displays, etc. The design of an experiment requires three steps: (a) creation of files, (b) trial definition, and (c) block definition.

Files

The first step in creating an experiment with the Experiment Writer is to create source files with a simple text-editing program. These files can be text stimulus files, point stimulus files, correct response files, or special character set files. Text files contain the characters, words, phrases or lists which are to be the stimuli for the experiment. Information to position the text on the scope, to select the type size (there are four), the character set (upper case, lower case, Hebrew, etc.), the brightness, etc., is put into special header lines in the file. Stimuli may also be defined as sets of x and y coordinates on a 512 x 512 grid to be superimposed on the face of the oscilloscope. Geometric figures may be defined in this way in a point file. Correct response files contain lists of correct responses to be used in computing feedback and summary statistics. Special character sets can be defined so that the user can plot text using non-standard characters. For example, the Cyrillic alphabet could easily be defined in a character set file, and used for writing Russian words on the scope.

Once the necessary files have been created, the Experiment Writer is loaded. The first phase of the Experiment Writer process is the file acquisition phase. The user types in the names of his source files and the Experiment Writer reads them into memory, checking for syntactic errors as it does so.

Trial Definition

When file acquisition has been completed successfully, the Experiment Writer proceeds to the trial type definition phase. Up to ten conditions can be defined using a set of ten simple commands. Some of these commands are described briefly here. The SHOW command is used to display a string of text or a stimulus from a text or point file on the scope. Stimuli can be selected from these files either sequentially or randomly without replacement. The FEED command displays the subject's reaction time in milliseconds, on the scope. If the subject's response was incorrect, the reaction time is preceeded by a minus sign. The DELETE command erases displays created by the SHOW or FEED commands. The TURN ON command turns on specified switches or sets of switches in the switch bank. The TURN OFF command turns a switch or set of switches off. The WAIT FOR command is used to time intervals. The interval can be given as an absolute number of milliseconds, or it can be given a variable name and be defined at run time. The ALLOW command permits responses to be recorded from a set of keys and initiates timing of the subject's reaction time. The WAIT TILL command delays the experiment until the subject responds. Provision is also made in the trial definition phase for specifying which stimulus numbers, reaction times, and response numbers are to be saved in the data file.

Block definition

The final step in building the experiment is to establish the sequence of trial types that will constitute a block. This is the block definition phase. Some fixed ordering of trial types may be specified or a mixture of trial types can be defined and sampled randomly without replacement. The experiment is now complete and can be saved and run from this point at any time. After each block of trials, the number correct, incorrect, and the mean reaction time for each condition is printed out. The raw data is saved in a data file and can be analyzed later.

A complete example of an experiment created by Experiment Writer is given below. The experiment is a very simple one. A plus sign which serves as a warning signal will appear on the scope for a brief interval. After an interval of blank screen, a pair of lower case letters will appear. The subject must press the left key to indicate they are the same letter, or the right key to indicate they are different. His reaction time will then be displayed. A minus sign will precede the reaction time if the subject made a mistake.

Two stimulus files will be needed. LET will be used for the different condition. It has the following appearance:

CHAR=1,X=240,Y=220,SIZE=1

-4 1

A

B

C

D

LET2 will be used for the same trials, and will look like this:

CHAR=1,X=240,Y=220,SIZE=1

4 1

AA

BB

CC

DD

The correct response for different trials is always 1, and the correct response file FNO will have the following appearance:

TYPE=2,X=232,Y=220,SIZE=1

1 1

1

The file for correct responses to same trials will be identical, except that 2 is now the correct response:

TYPE=2,X=232,Y=220,SIZE=1

1 1

2

The dialogue with the Experiment Writer is shown below. Text typed by the Experiment Writer is underlined to distinguish it from text supplied by the user. The symbol ↵ stands for a carriage return. Comments appear occasionally on the right hand side of the page to clarify the proceedings.

WRITER

FILES=LET,LET2,FNO,FYES — Source files are read in

SPACE=2556

FILES=↵

TRIALS

1=SAME — Same condition

* SHOW (+ FOR 1000

LET = 33811

RN = 34427

BLKS = 1

TIMES

ITI = 1500

SAME

1 = 10 577 0 0

2 = 0 0 0 0

DIFF

1 = 0 0 0 0

2 = 9 768 1 558

BLKS=

The subject made one mistake in the different condition. His mean reaction time was nearly 200 msecs faster in the same condition.

Detailed Laboratory Sequence

We desired to introduce the students to experimentation within the very first week of the course. Moreover, we felt that their initial work should introduce them to two aspects of experimental inquiry. First, the problem of variability which is characteristic of psychological research and second, the logical relationship between the psychological question being asked and the experimental design.

To meet these requirements we had students perform two experiments on the PDP-10 computer. The PDP-10 was programmed by us to simulate the responses of a subject. We found it possible to give our novice students sufficient information to work with the PDP-10 in less than one hour. The first experiment involved the measurement of sensory threshold. The experimenters presented the computer with a number which simulated the intensity of a stimulus. The computer responded to variations of intensity by typing either yes or no. The students were required to develop a psychophysical method to determine the threshold. A Gausian noise distribution simulated the frustrating tendency of humans to respond differently to the same physical stimulus. The students were surprised that a lawful program could provide so much variation. They learned that a lawful function could be induced from the data despite the noise present.

The second experiment also used simulation on the PDP-10 and was an adaptation of one first run at the University of California at San Diego. The simulation is of 'lateral inhibition' within the visual system of the limulus. The student can stimulate each of ten neural receptor cells with separate physical intensities. By programming these experiments they can discover the spontaneous firing rate of each neural cell and the inhibitory interactions between adjacent cells. Usually this part of the experiment proceeded rather quickly. Students then were asked to "discover" the kinds of functional significance which the wiring diagram had. For example, most found sharpening of boundaries and a functional relationship between firing rate and physical intensity. Here the students were able to see that even a full grasp of the underlying wiring scheme did not provide an understanding of its significance at the level of perception and behavior. The limulus experiment was noise-free and concentrated upon the logical analysis of successive experiments designed to explore a phenomenon.

With this background the students began to run each other as subjects on the PDP-15. The initial experiment was adapted from George Sperling and illustrated the characteristics of iconic memory. We found that only one hour of introduction was necessary to allow students to understand the PDP-15 sufficiently to control the study once we had programmed the basic experiment. They were allowed to manipulate the exposure duration of the array and the time between the end of the array and an arrow which told them which line to recall. All students were encouraged to study the decay of iconic memory, but other questions such as the effects of which line was probed, exposure duration, and serial position of the items were left to the student. Since the course material provided a background on iconic memory the

* ↑SIZE=1,X=248,Y=240	The + sign is centered above the letter pair
* FOR 500	
* SHOW LET2!$ TILL 5-6$#	Stimulus selection will be at random without replacement; stimulus number, reaction time, and response number will be saved.
* FEED FYES FOR 500	
* FOR ITI	
*	
2 = DIFF	Different condition
* SHOW (+ FOR 1000	
* ↑SIZE=1,X=248,Y=240	
* FOR 500	
* SHOW LET!$	
* SHOW LET!$ TILL 5-6$#	
* ↑X=256	Second letter must be positioned right of first letter
* FEED FNO FOR 500	
* FOR ITI	
* ↲	
3 = READY	The word "READY" will signal the start of a block
* SHOW (READY TILL 5-6	
* ↑X=176	
* FOR ITI	
* ↲	
4 = ↲	
SPACE=2425	
TITLE=SMALL LETTER MATCH	
BLOCK	
*1 READY	
*1,RN-10 SAME,10 DIFF	A block will consist of 10 SAME and 10 DIFF trials intermixed in some random order
* ↲	
SPACE=2389	
SMALL_LETTER_MATCH	
DATA = ↑Q1	The experiment is saved on DEC tape and can now be restarted at the title line at any time.
SMALL_LETTER_MATCH	
DATA = S1D1	
RAND#S	
LET2 = 11381	

students were able to get a first hand familiarity with the phenomenon they were reading about.

The next experiment was designed by the class itself. We introduced the relation between information and reaction time. The students then designed an experiment which varied the probability of each of four events. All students ran a standard experiment in which event probability and the time between the response and next stimulus were both varied. Individual teams were left free to explore such topics as the effect of repetitions, types of errors, transfer between probability levels, etc. The computer system was extremely powerful in making it possible to run the standard experiment in just 15 minutes of computer time. Automatic calculation of means facilitated pooling of data from the whole group.

At this point we began to train students to gain full control over the computer by use of Experiment Writer. Two lecture-discussion sections were sufficient to give the needed information. The first session taught students how to create files of the stimulus material they wished to have displayed. The second session taught them to create block definitions which sequenced events on the face of the oscilloscope and recorded various material on DEC tape.

The students were given practice in the creation of arrays during their fifth experiment entitled divided attention. In this study we created a general program which displayed simultaneous pairs of visual items to the left and right of a fixation point. The pairs could be sequenced at rates chosen by the student. Students were required to develop arrays which would illustrate points in the study of divided attention. For example, they could present pairs of digits at varying rates for immediate recall, or they could shadow one set of words and observe what they retained about the other set. Or they could develop a sentence, the words of which switched from side to side. The effort was to allow them to observe the phenomena of divided attention and to learn how to create arrays and store them in the computer for later display.

The final examination for the students was conducted as follows. They were provided a paper by Saul Sternberg which taught how to use an additive factor method of latency analysis in investigating a broad series of problems ranging from developmental psychology through hemispheric functioning. The students were asked to apply this method to an area of their own choice. They then wrote a research proposal outlining an experiment and how it would be conducted and analyzed. Using the Experiment Writer they were encouraged to create an array and assemble a complete block of the experiment. They were given approximately the last two weeks of the course to carry this out. They worked individually but many had consultations with us. During finals week each student presented his proposal orally and most ran a block of their experiment.

Course Evaluation

Two types of evaluation of the course are currently available. The first was the results of the final examination. Nineteen students completed the final. Of these, sixteen presented at least one block of an operating experiment on the computer. The course instructor rated five of these experiments as sufficiently exciting to contribute new information to the literature if correctly performed. The fact that two of the best experiments were those that were not programmed by the students led us to conclude that the requirements to program the final might be inhibiting the creative design of the experiment which is our primary goal. Nevertheless we were reasonably satisfied with the final results. More evidence will come from the ability of these students to choose good projects and execute them during the remainder of this year.

A second source of evaluation is from student opinions about the value of the course. The comments which follow are based upon (anonymous) student responses to two formal course evaluation questionnaires as well as upon opinions expressed informally to the instructor and his assistants.

Students spoke highly of the course as a whole. When they were asked to rate "the probable long-range value of this course for you" on a seven-point scale, eleven of the fourteen who responded used the two most favorable rating values (labelled "extremely satisfied" and "very satisfied"). No student expressed general dissatisfaction with the course.

No doubt this course was difficult and time-consuming. Every student indicated that he had been stimulated to work either "above" or "very much above" his usual effort level. Several suggested that extra credit be given for the course. Others felt that an intoductory course in experimental methods and/or cognitive psychology should have been offered prior to this one. But no one expressed regret at having taken the course. Typical comments were: "the course is difficult, but in the long run, very worthwhile." "For someone with upper division preparation, I would definitely recommend the course."

During the term, several questions arose regarding the emphasis which the instructor should place on various aspects of this course. Students answered some of these clearly, but stood divided on others.

For example, very little statistics instruction was provided, but students indicated they wanted more. Some students knew how to access prepared statistics programs on the PDP-10 and PDP-15, and others learned this on their own. But some formal statistics instruction will probably soon be added by popular demand.

Another question of interest was: Is skill with computers being overemphasized relative to the general skills of experimental design and to the subject matter of cognitive psychology? This question was asked of students indirectly, by requesting from them a percentage breakdown of the importance they personally place upon various aspects of the course together with an indication of what they perceived our weighting of these same aspects to have been. When they were asked to weight the importance of learning general principles of experimental design versus that of "exposure to computer facilities and their potential," five students indicated that more emphasis should be placed on the former, three wanted increased emphasis on the latter, and the other six respondents seemed satisfied with whatever they perceived our emphasis to have been. On the average, students felt that we had placed slightly greater emphasis on exposure to computer facilities. Students again differed widely in their weightings of "subject matter of cognitive psychology" versus "skills of experimentation" (the latter included statistical analysis, design of experiments, and exposure to computer facilities). Estimates of relative importance to the student ranged from 75%-25% in favor of subject matter to 70%-30% favoring skills of experimentation. Here, seven students were satisfied with our emphasis, which was perceived to have been about 50%-50%, while four wanted more emphasis on subject matter and the other three wanted increased emphasis on skills of experimentation. Our question was not clearly answered.

Finally, we wanted to know which of the six laboratory exercises were most worthwhile, and which ones we ought to consider replacing. We therefore asked students to make four rank-orderings of these labs along the dimensions of enjoyment, effort invested, understanding of purpose and technique, and overall worth. The final exam was ranked a clear first by almost everyone in all four aspects. The more complex experiments, done on the PDP-15, ranked much higher on worth, enjoyment, and effort than the first two PDP-10 experiments. The experiments on threshold determination and divided attention ranked consistently lowest. Some students commented that these labs were too unstructured.

Many of these detailed criticisms can be met by refinements in the course with more options available for students with different goals. The use of the computer facility opens up promising opportunities for individualizing the instruction even more than we have so far done.

NOTE

* The Experiment Writer program owes much to the work of Stephen J. Boies, IBM Research Center, Nancy Frost, Princeton University and Joe L. Lewis, University of Washington. We gratefully acknowledge their assistance. Indirect support of this work was obtained from research grants and facilities provided by the Advanced Research Projects Agency of the Department of Defense, monitored by the Air Force Office of Scientific Research under Contract No. F44620-67-0099 to the University of Oregon.