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ABSTRACT

The traditional approach to teaching experimental psychology has emphasized laboratory instruction. But too often this means most time is spent on handling rats or wiring circuits. Students would better learn how psychologists think by designing their own, open-ended problems rather tahan duplicating classical experiments. Since this approach is certainly expensive and possibly not efficient, a partial solution is a computer-based simulation game, which lets a student make some of the kinds of decisions a psychologist would make in collecting data relevant to the problem under discussion. This system leaves out the task of data collection, which though valuable often takes up too much time in an introductory course and also should perhaps be taught separately. The particular task in the DATACALL game is to determine which variables have effects on the outcome of a phenomenon and how big they are. Students play against the computer, and their results are posted so they can be discussed by other students. Advantages of this technique are: 1) rapid data acquisition allows many rounds of practice and more complex designs to be run than would be possible in the usual way, and 2) students are motivated to learn about statistical techniques because they see their relevance to their decision-making. (JK)

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DATACALL: A Computer-Based Simulation Game for Teaching Research Strategy

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The title of this symposium is "New Methods of Teaching Psychology Through Simulation and Games", but neither of these approaches to teaching is really new. The military has for some time used these types of training exercises and more recently the technique has gained a foothold in business administration, economics, and even more recently, political science and sociology. The newness of the approach refers really only to its use by psychologists in the particular applications described here. My purpose in communicating with you here today is to open up the possibility of exploring these modes of instruction more thoroughly in psychology. We have developed and begun using several different forms of a simulation-game over the past two years at Earlham which has seemed to have some promising results. I want to describe some of our experience for you in the hope that you may be interested enough to test the approach and certainly the preliminary conclusions that I have formed.

How does one come to get involved in teaching by simulations and games? We all have known, since the time we left childhood, that games are frivolous; and anyone who examines a simulation carefully finds it a fake. What is there in these techniques that could possibly recommend them to a serious teacher? My involvement occurred through successive attempts to improve laboratory instruction for beginning undergraduates.

The experimental tradition in psychology has, from its beginnings, emphasized the training of students through laboratory instruction. In many instances, however, it is difficult to see what we are attempting to accomplish in the initial exposure to the laboratory. Do we want students to learn how to handle rats, manipulate memory drums, or wire circuits? I suspect none of us would admit that this is all we expect, although often a great deal of the student's time is taken up with tasks like these. Is it that we wish to prove to students that we were not

lying when we said that rats can be shaped and humans will submit to and learn nonsense syllables? Perhaps letting students see data with their own eyes may be a part of it, but certainly not all. I suspect that most of us would allude to far broader goals relating to the nature of the discipline and the scientific method.

One of the goals we have consistently aimed for in our beginning courses in psychology at Earlham is to acquaint students with the way psychologists ask questions and go about attempting to answer them. A part of understanding any field of man's knowledge involves not only acquiring a catalog of the facts presently known in the field, but also beginning to grasp how men have come to know these things. What we know is not independent of how we know it, and for this reason we have tried to get students to think like psychologists in attempting to answer questions. However, the most usual, introductory laboratory approach we have found to be highly ineffective. Giving students "classical" experiments to "replicate" leads to student behavior patterns that mimic some of those associated with psychologists in the laboratory, but in terms of getting them to think like psychologists, the result is not as clear. It is as if we were trying to teach some one to be a composer (or at least know what composing is) by having him play several classical pieces. Just exactly what is it we think the student is learning as he goes through the cook-book steps of the typical laboratory manual? Perhaps this approach will suffice if we believe that science is a ritual to be learned or an algorithm to be memorized. But if we believe that doing science involves solving problems, and if laboratory instruction is aimed at having students experience and solve problems in psychology, then we need

to give students open-ended problems and challenge them to design solutions. This is nothing new. The student project approach has been advocated by a number of good teachers for some time. The major problem with this approach is the greater costs associated with developing and carrying out open-ended student projects. Realistically, in this period of tight budgets, we need to evaluate the cost-effectiveness of any mode of teaching which typically requires more costly space and equipment as well as a higher faculty-student ratio. Developing open-ended laboratory problems for beginning undergraduates is not efficient economically, and I suspect may not be efficient pedagogically. While the approach may be highly useful for training advanced undergraduates and graduate students, we still have the problem of what kinds of experience would best prepare students for later independent research.

A partial solution to this problem for me began to emerge in the summer of 1968 when I designed a computer-based simulation game. The general idea behind the game is to give the student a simulation of some problem area in psychology and allow him to make some of the kinds of decisions that a psychologist would make in collecting data relevant to that problem. One of the main advantages offered by simulating a system is that some aspects may be left out. My simulation of psychological experimentation was built to leave out data collection. This means that the expensive equipment and special laboratory space commonly associated with data acquisition can be eliminated for this aspect of the teaching. However, there is an even more important advantage to leaving out data collection. The major expenditure of student time in the usual laboratory is involved with data collection

rather than learning the logic of experimental design. While I do not deny the value of a student's "getting his hands dirty" by collecting "real" data, it is not at all clear that this experience should necessarily be a part of a student's initial introduction to experimentation. There are two issues which we might pause to consider before moving too easily to the conclusion that initial laboratory experience must involve data collection: 1) Efficiency in Instruction: Given a limited period of time, how should the student's laboratory experience be allocated? In the typical laboratory situation the student will be expected to spend the greatest proportion of his time in data collection. If it is the case (as it is with most skills) that the learner needs to have a number of repetitions or trials in order to learn the strategy of experimental design, then the major period of time given to data collection may prevent adequate practice for the learning of experimental design. One way to meet this problem is to extend the period of time of practice over a number of terms or years as is commonly done with majors and graduate students. However, this does not meet the problem of the student who will not be able to take such an extended series of courses in psychology, and this process may also be an inefficient way of doing this job even for the major. 2) The Programming or Design of the Learning Task: Is the best way to teach students how to do psychological research simply to start them doing it? Psychologists have learned a great deal regarding techniques for training lower animals to do very complex chains of behavior sequences. Some of the major findings that we commonly apply

to lower animals suggest that when the task is complex enough, we should almost never give the animal the entire task at the beginning of the training, and the temporal sequence involved in the task itself may not be the appropriate temporal sequence to be used in the training. If the skill we label "doing research" in psychology is a complex task, then it may be that we ought to break it down into manageable pieces and work out the appropriate training order rather then merely starting the student doing something and hoping that by a large number of repetitions he will learn. It may be pedagogically more sound to introduce students to the general logic of problem solving in psychology before they become too deeply involved in learning the intricacies of data collection for a specific experiment. I have had students in the past who focused so completely on how to handle rats, or use a particular piece of apparatus, or the enormous problems involved in collecting a particular type of data, that they lost all sight of how they planned to develop conclusions from any data which they might collect. From this I am suggesting that students start by learning the related logic of the beginning and end points of any experiment, i.e., the way the planning which we call experimental design links to and determines the conclusions which can be drawn from any set of data. Once students have this firmly in hand, then we should be able to proceed to data collection.

Simulation offers a further advantage beyond the efficiency of introducing students to the decisions involved in experimental design. Because the simulated system with which the student is interacting has

been built artificially, it can be closely controlled by the instructor. Situations can be developed which would not be feasible to explore in the normal laboratory situation, and the simulated system can be adjusted to grade the difficulty of the problem and lead students to explore particular types of materials, or particular types of experimental designs. While all of these things are possible using natural systems and real experiments, it is much more difficult to develop the right experiment, and typically, only a few such experiments can be explored within a given period of time.

A variety of computer programs can be written which will simulate phenomena in psychology. The way the present program works is to suggest that a number of variables can be treated as operating in an additive fashion to determine a particular output. I have thought of my computer program as doing an analysis of variance backwards, i.e., starting with the basic draw or residual variability and successively adding in the effect of appropriate variables. If a student chooses a particular value on a given variable the computer uses this value to determine that component of the effect. However, for any value that the student does not choose, the computer will draw randomly from the appropriate probability distribution to determine what value the student will get and then plug that effect into the equation (see diagram). Under these conditions, the student's task is to determine which variables have effects and how big they are. He does this by deciding which variables he wants to control and what values he will

set for these. The set of decisions that he turns in constitutes his experimental design, and these decisions are entered into the computer program to determine the output.

While the above approach may be somewhat unusual as a technique for introducing beginning students to the strategy of research, the use of simulation to analyze some problem area is not uncommon for advanced students. However, DATACALL represents more than merely moving the technique of computer simulation down to an earlier level in the student's work in the laboratory. A key factor in the use of the present simulated system has been its being embedded in a game format. Games have been used for some time to teach military strategy, the effects of various kinds of international political decisions and the outcomes related to various business decisions. The advantages of the game format seem to be two-fold: 1) Since games have goals, the activity of the players can be focused along particular lines; and as a corollary to the existence of goals, there is a built-in feedback system so that players know how well they are doing in relation to meeting the particular goal, i.e., "am I winning the game?" 2) Games have artificial rule structures which can be used to constrain the activity of the players along desirable lines and to explore the implications of a rule structure as an axiom system covering some field of human interaction (i.e., do the rules made explicit in the game mirror real constraints in the simulated system, and what are the implications of these constraints on how the system operates?).

The DATACALL simulation was turned into a game by setting up a

cost or ante which was associated with each decision made by a student and a corresponding payoff for the kinds of information that could be derived from the data of the experiment. Specifically, for any experimental design turned in there is a cost which increases directly with the number of pieces of data the student calls for and the kinds of limitations he puts on the variables in question. If he is able to discover a significant difference in the data he receives, he gets a payoff of 200 points. For a non-significant difference he receives only 40 points. Thus, the general strategy he needs to adopt is spend the fewest points in making his decisions consistent with obtaining the maximum information and payoff.

The way the game is set up, an individual student is "playing against the computer" although any number of students can play the game simultaneously in parallel. While this format of game play would appear to be ideal for interactive computer processing, we have had little experience in this mode thus far. Instead, the students have been free to turn in experimental designs at any time, and then these were punched into cards by lab assistants and batch processed so that the data was returned on the next class day. In this fashion a student is automatically assessed the ante for his experimental design when he turns in his set of decisions. However, as we played the game last year, no payoff was given the student until he handed in a single page laboratory report on his "experiment." We then posted these laboratory reports in a lounge area so that all students in the class had access to all other students' "published" results.

This led to a great deal of student interaction in discussing results of various members of the class in deciding on which types of designs are better and what questions ought to be asked next. To insure that students would not merely copy an already existing experiment "published" by another member of the class, a decreasing payoff function was set up for successive replications of the same experiment. This led to some very interesting student interaction. Some students wanted to wait for other students to do research so that they could read their "published" results before starting their own experimental program. However, this approach meant that ideas they had on questions to be asked might already be researched and "published" before they got around to running the experiment. There was some complaining in the class at this time about my having established an atmosphere of "publish or perish." Another feature of having the students' reports posted was that one student, in reading the results of another student's experiment, could try to replicate the experiment to see if the student's results were justified. We had set up an increased payoff for proving another student wrong in the claims that he made in his research report. We then had several students try to replicate experiments of others when they doubted the results.

There were several characteristics of the student behavior occurring in the play of the game that appear to be highly desirable from the point of view of learning to do research. 1) Students became very aware of the riskiness and tentativeness of experimental research and very sensitive to the fact that the kind of experimental design

they set up has a great deal to do with whether or not they will be able to draw any conclusions. 2) Because any research report turned in had to have an appropriate data analysis, all students became familiar with the statistical techniques of data analysis and got a great deal of practice analyzing data. Along this line, I might mention two phenomena that we have never observed in introductory classes before. First, a number of students in the class went to the library and took out statistics books voluntarily in order to learn more about the job of data analysis. I had not suggested this and the only reason I know that this occurred is that in at least two cases, students came to me to ask me to explain a particular part of the book to them. Thus, this approach to teaching seemed to function as a motivator for learning about particular techniques of analyzing data. Second, about one quarter of the class began using more complex experimental designs involving analysis of variance. After the game had gotten under way a number of students came to ask me to teach them analysis of variance so that they could design more complex experiments. Other students learned the technique by themselves. I also observed individual students figuring out specialized kinds of experimental strategies to try to reduce their costs. Some students ran pilot studies while others became very interested in reduced designs without my sending them to experimental design books to look at Latin Squares, etc.

The major advantages to this approach to teaching the decisions involved in research design are: 1) The rapid data acquisition of the

simulated system allows many rounds of practice and more complex designs to be run than would be possible in an ordinary laboratory sequence. I have had students run as many as seventeen experiments in two weeks, and other students who developed four-way factoral designs. There is no question about the fact that students get a great deal of practice in both deciding on designs and drawing conclusions via statistical techniques. 2) The game seems to serve as a motivator for certain kinds of behaviors that might not have otherwise occurred. In attempting to cope with the demands of the game, students find that statistical techniques suddenly become very relevant and they are motivated to learn more about statistics and how to use them. Others have also become very interested in the interaction of statistical techniques and the kinds of designs and questions that they wish to ask. I have gotten into some lively discussions with some students concerning the whole model of hypothesis testing. All of these kinds of outcomes I have never observed in introductory laboratories in the past.

While the games we have so far experimented with are relatively limited in scope, the general technique seems to be far broader. Thus, the approach may have application in other science fields; there have been some initial experiments tried out at Earlham in both Physics and Chemistry more recently. It is also obvious that the simulation can be embedded in a wide variety of games leading to different kinds of student behaviors. It is possible, by the appropriate arrangements of payoffs and costs to develop cooperative or competitive games and to

get the students to focus on one aspect or another of experimental design.

It may be that the very best approach to use of this teaching tool will involve a type of game format with which we are presently experimenting. Because one of the most critical questions to be asked of any form of teaching by games is whether or not it will transfer to the real situation, we have recently become very interested in what I call forced transfer games. In this type of game the student is given a limited period of time in which to work with one game problem and then is immediately given a new game problem again for a limited period of time. The idea behind this approach is that the student, if he is to be successful across a wide variety of game problems, cannot learn merely the specific solutions to a particular game, but must also develop general game strategies. To the extent that the student can master this transfer problem and move to the final transfer stage, real experimental problems, this type of simulation gaming will have served its purpose to introduce in a more efficient fashion the ideas behind the strategy of experimentation.

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