DOCUMENT RESUME

ED 039 748 | 56 | EM 008 083

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TITLE	The Psychological Heuristics of Learning.
INSTITUTION	Academy for Educational Development, Inc., Washington, D.C.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Bureau of Research.
BUREAU NO	BR-8-0571
PUB DATE	[70]
NOTE	20p.; This is one of the support papers for "To Improve Learning; a Report to the President and the Congress of the United States by the Commission on Instructional Technology", ED 034 905
EDRS PRICE	EDRS Price MF-$0.25 HC-$1.10
DESCRIPTORS	*Computer Assisted Instruction, *Educational Psychology, *Learning, *Programed Instruction, *Teaching

ABSTRACT

Efforts to apply knowledge gained from the study of the psychology of learning to actual teaching have been largely marked by frustration--until recently--when programed learning and its special derivative, computer assisted instruction, made their appearance. In programed learning you know where the student is and what he is doing, and what he learned. Computer assisted instruction goes one further: it can make computations so that an analyzed record is available for each student at any time. There are apparently no limitations as to what a computer can be used to teach. Computer assisted instruction is soundly grounded in what we know about learning. It will not make the teacher dispensable, but it will alter his role so that the teacher is released to do that which only the exceptional teacher now does well. (Author/GO)

THE PSYCHOLOGICAL HEURISTICS OF LEARNING

Ernest R. Hilgard *

Because we are discussing the teaching process today, rather than the finer structure of what goes on in the brain when you learn, my paper has been given the title of the "heuristics of learning," which means that I am to discuss what generalizations have come out of the laboratory studies of learning that bear upon the practical problems of encouraging someone to learn, and of helping him to do so. In the present-day language of science, we are somewhat out of the basic science area into the applied science or R & D portions of the spectrum.

Most of us agree, on the one hand, that the motivation of the basic scientist should be to direct his search for understanding and ordering natural phenomena wherever his discoveries or hypotheses may lead him. On the other hand, most of us take some satisfaction in the ultimate payoff of science through its applications; we are pleased about scientific medicine, no matter how worried we may be about other aspects of technology. What Robert Merton has aptly called "the potentials of relevance" are there in basic science, whether or not the scientist is himself concerned about them. This is doubtless true when he chooses to work on a topical field such as learning; surely the understanding of the basic problems of learning is potentially

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relevant to such practical problems as the acquiring of skills and of knowledge, and learning how to solve problems.

Until recently, the payoff from the basic study of learning to the applied areas has been quite limited, to the embarrassment of some of us who have worked on learning for many years. The topic has been one of high prestige within experimental psychology, perhaps the favorite topic for laboratory study over the last 30 years. Yet when it comes to teaching reading, writing, and arithmetic, the advances owing to this enormous investment in the science of learning have had but slight consequences. We know a great deal about how a white rat learns a maze, but when we teach a boy to ride a bicycle, we give him the bicycle and let him teach himself, without worrying about our carefully studied principles of task analysis, distributed practice, or prompt reinforcement. When we attend to the heuristics of learning we are more interested in how the boy learns to ride his bicycle than how the rat learns to thread his way through the maze.

If I call attention first to the failures of the psychology of learning, I do not wish to give the impression that all is lost, for I believe that some of the contemporary developments are very promising. But let me first call attention to these failures.

Many of us are college or university teachers, and most of us have participated from time to time in discussions on what makes a good teacher, and what arrangements are best for instruction. Higher education is big business, and there is no reason we should not introduce economies in it through some sort of cost-benefit analysis of different kinds of teaching. One obvious candidate for study is class-size. Despite the fact that the teachers most of us remember best from our undergraduate days are the brilliant lecturers, there is a lingering feeling that there are advantages in small class-size, ideally Mark Hopkins on one end of the log and a single student on the other end. Careful analysis of nearly 100 studies over the past 40 years leads inescapably to one conclusion: there are no demonstrable differences in results (judged by final examinations) of small classes versus large ones, of individual study without a supervisor compared with supervised individual study (Dubin and Taveggia, 1969). If we trust these investigations, which have been done with great care because the investigators knew the stakes were large, we would accept either the very large lecture or the non-instructor method, as the economical ways of teaching, just as satisfactory as any of the other methods we typically use. This is really a rather shocking conclusion. Doubtless the most costly and wasteful method of all is the large undergraduate teaching laboratory. These results strike right at the heart of cherished beliefs, so that most of the authors of the studies themselves back off from accepting the conclusions of their own studies. They think maybe the examinations are at fault (but they continue to use them) or that there are subtle aspects of human contagion that they do not know how to measure which would be sacrificed if we gave up small classes.

The same kind of negative result holds for studies of elementary education. There are no consistent differences to be found between teaching reading by the whole-word method or the phonetic method, we don't really know whether or not there would be advantages in using a different initial alphabet in English with beginners, or in post-poning the acquiring of reading until a little later, as practiced in Scandinavian countries and in Russia (Chall, 1967). We are so eager to start early that there is some pressure to go the other way, and to push reading instruction into the kindergarten. The point is that an established science of the psychology of learning is of very little help to us on these issues. This is a serious matter, and somewhere along the line suggests a failure of psychologists, in collaboration with educators, to develop a <u>responsible</u> applied psychology of learning.

Let me summarize the "state of the art" as of about 10 years ago.

(1) There were thousands of experimental investigations of reading, but they had not led to agreement on the preferred methods of teaching.

(2) There were upwards of one hundred quantitative studies of college teaching, with the verdict that one method was no better than another.

(3) There were thousands of laboratory studies of conditioned responses, motor skills learning, nonsense syllable memorizing, with animals and human subjects, largely irrelevant to the solution of the practical problems, or at least lacking the inbetween experiments to make relevancy explicit.

The obvious need was not for more of the same, but for something different. There is no reason to expect new studies of the old kind to lead to anything more definitive than the old studies. The temptation is to continue, which is, I suppose, a common disease in what Kuhn (1962) has called "normal" science.

Some efforts were indeed made over the years to break out a little from the standard patterns. As the motion picture became cheaper and easier for the teacher to project, visual aids were hoped to provide new dimensions to teaching, and then the tape-recorder added the audio-dimension, so we had audiovisual aids (e.g., Brown and Thornton, 1963). Countless studies of these led to the same old conclusions: one method is as good as another (Schramm, 1960). Yes, people can learn from films, perhaps a little better than from a very poor instructor, but no better than from an average instructor. The hopeful thing in all of this is that people gathered together (or working alone) who want to learn, given some learning materials, can be shown to learn. The only problem is one of efficiency, and through the years notebooks, workbooks, laboratories, films, tapes, lectures, discussions, textbooks, have all helped people to learn, but never with any dramatic changes owing to the new technology.

Two new hopeful processes have come along which may indeed break this log-jam. The first of these is <u>programed learning</u> in general, and the second is <u>computer assisted instruction</u>, a special derivative of programed instruction.

Although there had been earlier teaching machines (Pressey, 1926, 1927), programed learning took off from the work of B. F. Skinner (1954, 1958). He had done authoritative work on what has come to be called _operant conditioning_, chiefly with rats and pigeons, but developed a few simple principles that could be applied to any kind of training procedure. He and his students have turned out to be remarkably effective applied psychologists of learning, despite the basic-science attitudes inculcated over some 30 years of precise studies of animal learning in the laboratory. Here, then, is the kind of payoff that a science of learning might have hoped for.

The applications have extended to animal training, a curious lack on the part of others who have through the years worked on animal learning. It is Skinner's products who train the dolphins and other performers in the various Marine Worlds which are now so popular. His methods are used in drug-testing in pharmaceutical houses, in psychotherapy with autistic children and with schizophrenics, and in many other areas of application outside the schools. The advantage of his particular kind of formulation is that it tells you what to look for and what to do, and these are the marks of a science on the way to becoming a technology.

Let me summarize the Skinner system of operant conditioning to indicate what I mean by its technological simplicity.

First, the learner comes to a given learning problem with something he can already do. Thus he may know how to count before he tries to learn how to add or subtract, he knows how to talk before he learns how to read, and so on. This is described as the operant level at the time a new task is undertaken. Operant level is, in fact, a very complex matter of prior training, of memory, of individual differences, of motivation, but it reveals itself by the responses that the learner makes when he begins the new task, and from the point of view of the teacher it is just a matter of beginning to teach on the basis of what the learner already knows and can do.

Second, because of this operant level the learner does something in the presence of the new task. He characteristically varies his responses somewhat, in accordance with what has traditionally been called trial-and-error. In any case, when he does something that approximates a desired performance he is given some sort of reward or reinforcement as it is called within this system. A reinforcement is anything which tends to increase the probability that when next exposed to the same opportunities for response he will tend to do what he last did; it may be an M & M, a pat on the back, or a verbal OK.

Third, absence of reinforcement leads to extinction, so that if behavior is non-reinforced its probability of occurring will be reduced, thus giving the opportunity for more appropriate behavior to appear and to be reinforced.

Fourth, by skilled use of selective reinforcement and extinction, behavior can be made to move from a crude approximation to a more refined and acceptable performance. This process of directing the behavior in desirable directions is called shaping, and represents the essence of the new technology.

A trainer or a teacher who knows about operant level, reinforcement, extinction, and their appropriate patterning in shaping, is ready to roll up his sleeves and go ahead. There are subtleties within the shaping process, such as the timing of reinforcements, the use of various schedules of reinforcement, and so on, but these are accessory principles, like learning how to tune the carburetor after you know how an internal combustion engine works.

While giving full credit to Skinner and his followers for the applied consequences both of his theory and of his inventiveness, let me point out that the theoretical support for his technology can come from sources other than his own theory.

Reduced to simplest terms, there are three major learning viewpoints which for some years have competed for attention in this country. (1) The first of these, for which Skinner is here the representative, is operant reinforcement. For the present I am letting this stand for some alternative but related interpretations of trial-and-error learning followed by reward, as espoused by Thorndike, Hull, Spence, Neal E. Miller. (2) The second, equally behavioristic, holds to contiguous association, without stress upon reinforcement. It is associated with Guthrie, and in the context of today's discussion, his disciples Lumsdaine and Sheffield. (3) The third and final view, called cognitive theory, is associated with Gestalt psychology, and Piaget, with Tolman, Bruner, and others.

An important set of developments in learning theory, known as mathematical models, with which the next speaker is identified are relatively neutral with respect to these global viewpoints, and I shall pass over any attempt to relate them.

I wish to point out that programed learning, and its variants in computer based instruction, derive some support from each of the three major views toward learning.

Operant reinforcement. In keeping with his conception that a response to be learned should be emitted rather than elicited, Skinner has commonly insisted that the learner in programed instruction should be responsible for his own responses, which in practice means that he should write out his answer, rather than selecting in cafeteria style from a set of answers someone else has provided. Then his teaching machine or programed book displays the right answer for comparison with the one he has produced; if they are alike he has been symbolically reinforced.

Another aspect of programing, deriving from the animal experiments, is the shaping of responses. A learner will learn to give more precise answers if at first approximate answers are rewarded, so that he knows he is on the right track and keeps working. In the laboratory, the rewards are gradually withheld for the inappropriate approximations, so that only the desired behavior is rewarded. Thus a rat can be made to press a lever with a limited amount of force, or to hold it in a prescribed position, in order to receive the pellet of food that is his reward. In the program the shaping tends to be done by prompting, that is by some sort of hint that makes it easier for the correct response to be emitted.

Contiguous association. Guthrie's theory of learning was also a beautifully simple one, which told you where to look and what to do, so that it was suitable to become a technology in the hands of its followers. According to him, the learner tends to do what he last did in the presence of stimuli, and new or associated stimuli come to elicit the response merely by being present (and attended to) when the response occurs. An associative shift can occur so that the old stimuli drop out and the new stimuli remain attached to the response. This is the heart of what we mean by learning. According to his supporters, the shaping that goes on through prompting is better understood in Guthrie's terms than in Skinner's. Fading is a technique lending itself to this interpretation. A word is first presented in skeleton form, with a few letters missing, to make it easy for the learner to produce the correct response. Later all letters can be omitted, for by this time enough new stimuli have become attached to the desired response that the old supports can be withdrawn. Lumsdaine takes the position that most of the efforts of the programer is directed to having responses occur without error (a feature that is stressed by Skinner also); in that case he believes that we are really talking about elicited rather than about emitted responses.

Cognitive theory. The cognitive theorist is impatient with a theory of learning that limits itself to talking about small steps, responding, and reinforcement. Surely any significant subject-matter has some kind of organization within itself that a learner must comprehend or understand if he has really mastered it. The cognitive theorist looks for the effect of the organization or structure of knowledge upon the learner.

Because the program constructor is likely to be talking the language of his technology, he may well fail to communicate all that he himself believes. Thus in stressing the reinforcement of responses he may in fact be neglecting to say anything about what is being learned.

The little responses that fill in the blanks at the end of a program, or the words that the student points out on the television screen with his electronic pencil are not what is being learned, although they may be <u>indicators</u> of what is learned. Suppose that in learning to extract the square root of 25 you get the answer 5, and write it down. The "5" then gets reinforced, because it is correct. Did you learn the response "5", or did you learn to extract the square root? When a rat runs a maze, and gets to the end-box, and eats the food there that serves as a reinforcement, is he learning to eat? Obviously the response at the end is merely a special output that shows that the essential responses along the way have been made, or, in cognitive terms, that the essential relationships have been understood. A program could be written that would have all the answers either the word "right" or the word "wrong", as in a true-false examination. Obviously more would be learned than to write the words "right" and "wrong". The point here is that cognitive learning can be taking place under arrangements of operant conditioning.

I believe that the advances made in programed learning, while catalyzed by learning theory, have not in fact been based very much on strict applications of specific learning theories. However, one should be careful not to disregard the technological approaches suggested by the theories. In this respect, the reinforcement and contiguous association theories have been dominant because of their insistence on stimulus control, identifiable response, and prompt feedback, so that the programer has instructions as to what he must do in order to help the learner. The cognitive theorist has been somewhat less successful in his technologies, although the lack of success is not owing to any necessary deficiency in the theory. For example, the cognitive theorist also has some technological suggestions such as beginning with less differentiated wholes before going to more differentiated ones, practicing on examples illustrating common principles within changing content (in order to encourage "transposition"), and so on. In fact, many of these principles become incorporated into the technological practices of those whose commitments are to the other theories. An interesting illustration of this is provided by the work of Sheffield and Maccoby (1961) who, while accepting Guthrie's contiguous association theory, when working within the context of producing a teaching film on how to assemble complex equipment, found it necessary to "rediscover" cognitive psychology, as in their insistence that the arrangement of learning had to be coherent with the inherent organization of the task if the learning were to be efficient.

Thus far I have talked about programed learning, essentially as conceived in its earlier form, progressing by small steps from where the learner is to where the teacher wants him to go. The early teaching machines and programed books tended to incorporate such procedures. These evolved from the laboratory experiments, which had usually set rather fixed tasks, such as learning a maze or memorizing a list of items in consecutive order.

Another kind of program developed very early, however, known as the branching program. All learners did not follow the same path through the program, but the next steps were contingent upon the earlier ones, and sometimes based upon the learner's preferences. It is out of such programs that computer-assisted learning evolved. The computer provides maximum flexibility, and as the next speaker will doubtless indicate, the computer is neutral in respect to the theories you wish to test. It is highly flexible, will do what it is told, and does not forget its instructions.

One early advantage of programed learning and the teaching machine, to which I have not referred, is that one has a record of progress, of errors made, of amount learned per unit time. This is in some respects the most significant advance over ordinary teaching methods. Most teachers really do not know what the learners are doing; they trust to a student's occasional smile or a nod of the head to assure that the student is listening; the questions that come up often as not show not that the student was listening, but that he really didn't hear what had gone before. When examination-time comes teachers are often disappointed because of their students' failure to learn, and pleased with what the brighter ones know--but they have little idea what their own teaching had to do with it. In programed learning you know where the student is and what he is doing; if he progresses through the program both he and the teacher have the satisfaction in knowing that he learned from it. Now computer-assisted instruction has not only this same advantage of keeping a record, but it has the further advantage that the computer can make computations so that an analyzed record is available for each student at any time. The details I leave to the others, but this advantage, if capitalized on, can prove enormously useful in preventing wasteful procedures.

I wish to address the rest of my remarks to the problem of the proper place I see for computer assisted instruction in the total educational process, and what I see as its limitations.

Let me first acknowledge the promise that I believe such instruction holds for the efficient teaching of all manner of skills, information, and appreciation. I see no limitation inherent in subject-matter as such; that is, such instruction is not limited to subject-matter with fixed answers, such as mathematics, grammar, map-reading, historical chronology, or foreign-language vocabulary. It is possible to teach poetry or creativity as well.

Now a few propositions regarding to relationship of such instruction to the total educational enterprise:

1. Computer-assisted instruction, even when fully developed, must be combined with other learning activities, and not displace them. To the extent that learning goes on in the library, or in the laboratory, or in the studio, it will and should continue to go on there. It should not be taken for granted that time in the library, or craft shop, or music-listening room is well spent; criteria that we have learned to use in studying computer assisted instruction may well be applied there also, but the chances that something can be done that cannot be done sitting at the computer terminal seems good.

2. Computer-assisted instruction is likely to be largely sedentary, for it is wasteful to monopolize a terminal while you are elsewhere. Much learning takes place on the hoof, or in conversation with a more capricious responder than the computer. If we are to encourage the spirit of inquiry, we want students to go to the library, to putter about the shop; to prepare them for responsibility we want them to meet together to make plans for group activity, to take part in plays and in team games. That is, learning by doing is not dead, and there are some "doings" that the terminal is unsuited for.

3. Teacher training will doubtless be greatly affected by the computer, because the things the teacher now spends most time on may very well be the tasks for which the teacher is least needed. We may therefore consider some of the things that a wise teacher might do better than a computer.

a. The teacher can take responsibility to see that the student learns to initiate inquiry on his own. While the computer can provide a range of opportunities, and can even engage in individual guidance, I doubt if it will ever do as well as a skilled teacher in fanning a faint spark into a glowing interest. Recent work on social learning theory (Bandura and Walters, 1963) has shown that imitation is one of the neglected areas in the psychology of learning, and the imitation of a teacher as an adult model may have great influence upon what is learned.

b. The teacher can help the student to gain a favorable image of himself as a learner and as a creative person. While the reinforcements of the computer will help, direct social approbation is an even more powerful reinforcer. I was greatly impressed by something that happened many years ago when working with young chimpanzees along with Professor Yerkes at the then Yale Laboratories of Primate Biology in Florida. So as not to introduce experimenter bias into the session, we were concealed behind a screen while the chimpanzee went about his puzzle-solving. He solved the problem, all right, and a banana appeared as a welcome reinforcer. He picked up the banana, but sought out the screen and peered behind it to show us the banana and get our commendation before he sat down to eat it. The "computer" had delivered his reinforcement, but he wanted ours in person. I suspect children are like that, too.

One way in which to engender creative expression is to modify excessive negative self-criticism through teaching the learner to take credit for and satisfaction in small evidences of creativity. We do not have to have distinguished products in order to be creative. This is something that a skilled teacher can have a share in, through adapting the critical appraisal to the stage of development of the learner. My guess is that not many teachers do this well, but that's why a different kind of teacher training may be necessary.

c. The teacher also has a role in directing the student toward effective partic pation with others. While I am against making everybody into extraverts, human life is inescapably social, and an effective person has to learn to cooperate with others in solving problems, in making plans, or in carrying out a cooperative enterprise, whether at home, at school, at work, or in the community. The skills of social participation, of leadership and of followership, of tolerance of opposition and of frustration, of social conflict resolution, can be learned only through exercising them. The discriminations are too difficult, the response interchanges too rapid, for them to be well programed. Even after social skills and practices have been studied through a program they have to be exercised or they will not persist.

What this amounts to, then, from what we know about how an individual learns, and how he can be aided by those who wish to aid his learning, is that computer-assisted instruction is soundly grounded in what we know about learning, although its usefulness does not arise exclusively from any one of the prevailing theories; it will not make the teacher dispensable, but will alter the teacher's functions in such a way as to require the usual teacher to do what only the exceptional teacher now does well. This is itself an important challenge to teacher-training institutions, as they prepare teachers for the schools of the future.

REFERENCES

Bandura, A., and Walters, R. H. Social learning and personality development. New York: Holt, Rinehart, and Winston, 1963.

Brown, J. W., and Thornton, J. W., Jr. (Eds.) New media in higher education. Washington, D. C.: National Education Association, 1963.

Chall, Jeanne. Learning to read: The great debate. New York: McGraw-Hill, 1967.

Dubin, R., and Taveggia, T. C. The teaching-learning paradox: Comparative analysis of college teaching. University of Oregon: Center for Advanced Study of Educational Administration, 1969. (To appear).

Kuhn, T. S. The structure of scientific revolutions. Chicago: Univ. of Chicago Press, 1962.

Pressey, S. L. A simple apparatus which gives tests and scores--and teaches. School and Society, 1926, 23, 373-376.

Pressey, S. L. A machine for automatic teaching of drill material. School and Society, 1927, 25, 549-552.

Schramm, W. (Ed.) New teaching aids in the American classroom. Stanford, Calif.: Institute for Communication Research, 1960.

Sheffield, F. D., and Maccoby, N. Summary and interpretation of organization principles in constructing filmed demonstrations. In Lumsdaine, A. A. (Ed.) Student response in programmed instruction. Washington, D. C.: National Academy of Science, 1961, 107-116.

Skinner, B. F. The science of learning and the art of teaching. Harvard Education Review, 1954, 24, 86-97.

Skinner, B. F. Teaching machines. Science, 1958, 128, 969-977.