SOME CRITICISMS OF AUTOMATED TEACHING

ARTHUR R. JENSEN

The recent boom in automated teaching has been accompanied more by optimism, enthusiasm, uncritical acceptance and rejoicing than by skeptical, critical, or negative attitudes. Most of the active enthusiasts appear to be among the experimental and industrial psychologists, while the critics and skeptics tend to be among the educators and teachers. To warn the reader of my own bias, I hold to the belief that the best policy is to maintain an attitude of maximum skepticism regarding the old, the traditional, the obvious, the self-evident, the "true and tried," and to exercise an attitude of tolerance and openness, enthusiastic curiosity, an optimistic expectancy toward new ideas, methods, inventions, and innovations. In science and education, as in the political realm, there seems to be a "liberal-conservative" continium. And both sides are needed for balance. The "liberals," if they are to behave intelligently, must consider the criticisms and cautions of the "conservatives." Since I have heard from teachers and educators a number of recurring criticisms of teaching machines, ranging from mild skepticism to outraged abhorrence, along with expressions of anxiety and the need for caution, I would like to examine some of these reactions. Before proceeding, however, it should be pointed out that one cannot properly speak of THE teaching machine, and when I do so in this paper it is only for convenience. Actually there are many types of machines, many based on somewhat different principles and having almost as many different capabilities.

The critics have a difficult task, for as far as I can determine there is nothing in our scientific knowledge of the psychology of learning which in itself would contra-indicate the use of teaching machines. On the other hand, there are a number of things we do know about learning which suggest that teaching machines may indeed have great promise. For example, we know that an active rather than passive attitude favors

learning, and teaching machines demand active participation of the student, otherwise the machine will not operate. Learning consists of changes in the subject's response repertoire, and responses, usually overt or covert verbal responses, must be made for learing to take place. The learner must be constantly active before the machine. Also in machine teaching no use is made of aversive methods of motivation. Children learn because they receive positive reinforcement, not because they fear the teacher's punishment or disapproval. We know that positive reinforcement (once called reward) produces many of the effects commonly attributed to high motivation. A rewarded child seems motivated, and rewarded behavior occurs with increasing frequency. The machine reinforces the subject's behavior, provided it is the desired behavior, at every step in the learning process, something no teacher can do constantly for every child in the classroom. We know also that immediacy of reinforcement is a potent factor in facilitating learning. The machine's feedback to the subject minimizes the delay in reinforcement at least as well as a private tutor sitting beside his pupil could do. The machine also permits each child to work at his own pace; the material to be learned is presented at a rate commensurate with the child's ability to grasp it. The sequence of steps in the program can be so planned with sufficient gradations from the simple to the difficult that nearly all children will have minimal difficulty in progressing through their lessons. When difficulties are encountered the program can branch into other simpler material that will further prepare the student for learning the new material. All this proceeds in accordance with each student's individual rate of progress. Finally, with teaching machines educational psychologists will be able to conduct research on the psychology of school subjects with the same degree of control and precision as is found in the experimental psychology laboratory.

Because the outlook for teaching machines is favorable from the standpoint of what we know about the psychology of learning, the critics of teaching machines

Dr. Jensen is an Assistant Professor of Educational Psychology with the School of Education, University of California, Berkeley.

have had to direct their criticisms largely at a number of straw men they themselves have set up. These consist mostly of attributing various undesirable characteristics to teaching machines or to the imagined results their use might produce. They are usually based on the critic's imagination of the worst features and outcomes that could possibly be associated with teaching machines. Think of how one could imagine the possible dire consequences of using telephones, automobiles, or electric lights! Other criticisms stem from an inadequate understanding of the nature and purpose of teaching machines, or from mystically vague and erroneous notions concerning the nature of learning. Then there is the semantically interesting fact that some persons have strong negative reactions against anything associated with words such as "mechanical," "automated," etc.; and these reactions are intensified when human beings, especially children, are mentioned in the same context.

Machines as Teacher Rivals

"Can Machines Replace Teachers?" The titel of a recent article in the *Saturday Evening Post* (September 24, 1960), exemplifies one of the most common misconceptions about teaching machines. Why the inference that the child will be deprived of contact with human teachers and will be confined to work with a mechanical gadget which cannot discuss, debate, encourage original expression, or handle the individual child's peculiar difficulties in learning? To my knowledge no one in the automated teaching field has advocated reducing the number of teachers or depriving the child of the kinds of experience which can be provided only by a human teacher. Indeed, teaching machines will free the teacher from the many routine chores such as drill, correcting papers, giving tests, etc., so that she may devote more time to her pupils on a more individual basis, spending more time doing those things that only a human teacher can do.

Teaching machines are sometimes criticized on the basis of their association in the minds of many people with B. F. Skinner, the Harvard experimental psychologist who has done a great deal of work on operant conditioning in rats and pigeons. But teaching machines need not be associated with any particular theory of learning at the present time. It is quite doubtful that Skinner's research on free operant conditioning is even very relevant to teaching machines, though, of course, he would not agree with this viewpoint. Skinner's contributions to automated teaching have resulted more from his enthusiasm and the stimulation he has afforded some of his colleagues who are engaged in research on the machines themselves than from his own classical research on operant conditioning with rats and pigeons, however important this research may be in its own right.

Does the teaching machine necessarily cause the learner to expect that there is one and only one correct answer to every item in the curriculum, or to believe that there is only one path to every solution? Not at all. Programs can be made so that the student learns many responses to certain items. In fact, it is possible for the student to learn to discriminate between types of questions that have single definite answers and questions that involve value judgments and necessitate discussion rather than call for ready answers. Any number of different methods leading to the solution of a problem may be learned by the student. It all depends upon what you put into the program. There can be good programs and bad programs, extensive programs and limited programs. Automated teaching *per se* does not imply the use of programs that are inappropriate or inadequate to our educational goals, any more than our traditional teaching methods imply the use of ignorant and incompetent teachers.

Does learning by means of a teaching machine minimize the transfer effects of learning? I can see no reason to suppose that machine teaching should have any less transfer than is produced by traditional teaching methods. Programs can be designed to promote transfer, by having the student apply in a new program what he has learned in related previous programs. Thus we would have much better objective evidence for transfer than we have at present; and research can reveal which types of programs produce the greatest amount of transfer. But even if teaching machines were good only for acquiring the specific vocabularly in each field of study, such as biology, physics, psychology, etc., it would still be of great value, since we know that ease of learning a given subject matter is related to one's familiarity with the vocabulary of the field. Students who had acquired some of the basic vocabularly in a subject

through a teaching machine could much better profit from the teacher-led classroom discussions than students who force the teacher to spend a great deal of the class time teaching vocabulary, a task the machine can accomplish more efficiently.

The idea that the machine can be used only for *rote learning*, while *understanding* depends upon classroom instruction is a result of the mystical dichotomy of "rote learning vs. understanding" which is still cherished in educational circles. Actually rote learning and understanding may be conceived of as different directions on the same continuum. Rote learning consists of the acquisition of a small number of responses (one, in the extreme case) to relatively simple stimuli which normally elicit limited responses from anyone. On the other hand, we say that a person understands something to the degree that he can make appropriate discriminative responses to the stimulus. But they are still responses and can be learned as are all other responses; and the more of them that the subject can make that are appropriate (*i.e.*, that will be reinforced by others or by the behavioral outcomes mediated by the verbal responses), the greater the subject's understanding. Understanding consists of multiple discriminative responses to a complex stimulus (*e.g.* a question), and further, discriminative responses to one's *own* responses. In the case of verbal responses, this is largely what "thinking" consists of. There is no reason why programs cannot be made which require multiple responses from the student and permit him to acquire those behaviors we call "understanding." The human teacher becomes important in the stage of understanding in which the student makes discriminative responses to his own verbal responses; such chained behavior requires differential reinforcement by a person possessing greater understanding if the student is to learn to "think for himself." This is where the value of teacher-pupil discussion comes in. Before progress in understanding certain subjects can take place, however, a good deal of learning toward the "rote" end of the continuum must have taken place, and teaching machines can fill the bill here quite efficiently. But it should be made clear that teaching machines are not confined in their use to the extreme "rote learning" end of this continuum. With the advent of teaching machines in education an urgent need is for a kind of taxonomy of the behaviors

(*i.e.* skills, knowledge, etc.) we wish individuals to acquire in the course of their schooling. Then we can find out through research which of these behaviors can be acquired most effectively by means of teaching machines and which behaviors depend upon classroom instruction.

Can teaching machines handle individual differences? Teachers have been taught the importance of providing for individual differences among their pupils, and any teacher with a class of twenty or more pupils spanning almost the entire spectrum of learning abilities certainly appreciates the meaning of the term. But the problem of individual differences is one which in fact the educational system has never solved. To assume for this reason that the problem of individual differences will be the Waterloo of automated teaching is unwarranted pessimism. Indeed, the facts should encourage optimism. With a machine, unlike classroom instruction, each child can progress at his own rate of learning; and programs of varying degrees of gradualness and with the possibility of "branching" for various types of remedial instruction should be able to provide for individual differences with an efficiency beyond the possibilities of a single teacher dealing simultaneously with twenty or so pupils. Theoretically there is no limit to the number of types of programs that could be used for teaching a given subject matter. So far, however, there is little indication that individual differences will constitute this much of a problem for teaching machines. Actually we know very little about individual differences in the learning process itself, except that they certainly do exist. We know a good deal about the differences in past learning with which children come to school, differences that are measured by IQ and achievement tests. But individual differences in the dynamics of behavioral change is an unknown territory at present. The writer's own research interest is an attempt to find out something in this territory. Teaching machines will certainly faclitate such research.

A skeptical attitude concerning the efficacy of teaching machines with culturally deprived children is another example of assuming that automated teaching will inevitably inherit the failures of traditional teaching methods. Until we try, we won't know how effective teaching machines will be with culturally deprived children. The one place where machines have been used

California Journal for Instructional Improvement

with such groups, in New York City, has yielded promising results.

The machine's possible limitations in training for originality and creativity are also invoked by the critics. Again, we know very little about the psychology of creativity, least of all how to teach it. Whatever creativity springs from the products of public education, progressive or otherwise, is certainly purely accidental. No one really knows the controlling variables in creativity. When we do know them, we can find out if machines can make any contribution to the acquisition of this kind of behavior.

In general, it seems that much of the criticism of automated teaching is based on the false notion that traditional methods have been successful and that the machine will have a high standard to compete with. Actually automated teaching would have to be very bad indeed to make a poor showing in comparison with traditional methods, for after twelve years spent in school a substantial proportion of students still can barely read, write, spell or do simple arithmetic. Educational standards should not be measured against the accomplishments of a generation ago or of other inadequate educational systems, but against the standard of what could be accomplished by the very best private tutors working assiduously with the individual child throughout his twelve years of formal education.

But even if automated teaching could do the best job possible, some persons would still object, as did one mother, when she said, "A machine teach my child? Not on your life! A child needs human warmth." Surely we hope that her child will not be deprived of human warmth at home and will have friendly and encouraging teachers at school. But it should be pointed out that textbooks and other educational paraphernalia, with which the student must spend a good deal of his time, possess no more human warmth than the teaching machine, which at least is an active, reinforcing partner in the learning process. As for the idea that we are "treating children like animals" by letting them learn with teaching machines, I can find no device essentially like teaching machines that has been used with animals. Certainly the Skinner box is not a teaching machine, nor is the Pavlovian conditioning stand. The only sensible interpretation I can make of this statement is that there has developed in psychology a common terminology and set of concepts for describing certain empirical relationships in the realms both of animal and human learning. This in itself is a worthy scientific accomplishment.

A number of criticisms and warnings I have heard warrant more serious consideration. The first is a rather technical point concerning the extent to which the learner should be prevented from making wrong responses in the course of learning. Some of the protagonists of automated teaching have held it desirable that the child be prevented as much as possible from making any incorrect responses. I believe there is insufficient evidence that this is the best arrangement for all kinds of learning. Answers to these questions as they apply to teaching machines must await further research.

The most immediate danger of teaching machines, I would agree, stems from the fact that the machines themselves are proliferating more rapidly than are good programs. The machines are easier to produce than the programs. If school systems buy these machines on a large scale before enough good programs are available, the pupils will suffer and so will the advancement of automated teaching. Programming is a highly technical problem requiring the joint efforts of psychologists, subject-matter and curriculum experts, and other educational research specialists. Automated teaching cannot be left solely in the hands of the machine manufacturers or of public school personnel without the research know-how to evaluate its products. Automated teaching must be tried out on a large scale in entire school systems on a research basis, with adequate supervision by educational psychologists and other specialists. Teaching machines, and especially their programs, are not finished products that one can install in the classroom with the same confidence one installs an electric dishwasher in the kitchen.

I think it is reasonable to assume that automated teaching is here to stay. In fact, its value has already been proved in training programs in the armed forces. But if it is really to pay off in desirable results in the schools, it will have to be treated on a research basis for at least the next several years. The more good research we have, the sooner will automated teaching fulfill its potential in the educational system. What research we already has gives us plenty of reason for optimism.