Current trends in programmed instruction for the mentally retarded

Mary Virginelle Dulko

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CURRENT TRENDS IN PROGRAMMED INSTRUCTION
FOR THE MENTALLY RETARDED

by

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A RESEARCH PAPER
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INTRODUCTION

Programmed instruction, a new technology of teaching, has recently emerged from findings in the psychological laboratory. It is concerned with the selection and arrangement of educational content based upon what is known about human learning. It is a process of constructing sequences of instructional material in a way that maximizes the rate and depth of learning, fosters understanding and the ability to transfer knowledge to new situations, facilitates retention, and enhances the motivation of the student. 1 Programmed instruction, unlike many of the nostrums advanced for education today, is a development by educators, for educators, and is firmly grounded on educational theory. This should be stressed if only because the popular press has sometimes given the impression that programmed instruction, and its vehicle for presentation, the teaching machine, are merely one more audio-visual aid--bigger, better, and technologically improved. They have also been heralded as innovations that will revolutionize education and have been branded as fads that will soon be replaced by something new. These positions are not well founded,

and later reports on programmed instruction have taken on a more moderate tone.

Programmed instruction has also been extended to the field of special education, including the area of mental retardation. Since 1960 interest in this mode of instruction for the retarded has increased steadily. In part, this reflects the utilization of a special population by champions of research in programmed instruction; in part, it represents an adventure into a new educational arena by some teachers of the mentally retarded. Both groups recognize the potential advantages of educational efficiency and economy that programmed instruction offers. Informed teachers of retarded children, especially, see that programmed instruction can provide relief from repetitive drill-type instruction to help retardates acquire basic academic skills.\(^2\) Currently, programs such as reading, arithmetic, spelling, and concept formation are being developed; and research is concerned with techniques employed in programmed instruction.

A major attraction of programmed instruction is the fact that students proceed at their own rate according to their own abilities; not only does the bright student proceed as rapidly as he can, but the slow student also works at the pace most efficient for him. Because of this characteristic, programmed instruction has a great deal of

merit in the training of mentally retarded individuals. Thus, not only can the technique be helpful to the "slow" individuals in public schools or special education classes, but if proper materials can be developed, it would be advantageous to the institutionalized mental retardate as well.

The concepts and principles of programmed instruction are relatively simple and few in number; the major problems seem to lie in developing materials and techniques which will permit their use with the retarded.\(^3\)

Purpose of the Paper

Programmed instruction is new to some, promising to many, puzzling to others, and perhaps a little frightening or alarming to all, but one thing is certain: it is being talked about. Recently it made its initial impact on the educational horizon as one of the most promising approaches to the particular learning problems of the mentally retarded child. However, the majority of teachers and parents of retarded children know very little about this new educational technology and much of the research with retarded children has not been widely publicized. Therefore, this paper is directed toward discussing programmed instruction as an educational method and has two objectives: (1) To evaluate the utility and feasibility of programmed instruction with a

mentally retarded population. (a) To explore the effectiveness of programmed procedures, i.e., to compare the achievement of mentally retarded children using teaching machines and programmed textbooks to equated groups being taught the same material by conventional special class techniques.

Principal Features of Programmed Instruction

The potential of programmed instruction as a possible mechanism for change in educational practice is now widely recognized, and there is an increasing acceptance of the new technology as a significant impetus in the redesign of instructional practice. Not only can today's teaching machines provide efficient instruction, but they are most significant as applications of the more general concept of programmed instruction.

The most important notion underlying the present excitement about teaching machines and programmed learning is that they urge application of what we know about learning to educational psychology. 4

However, before setting forth to discuss the principal features of programmed instruction one would do well to discover what it really is. How does it differ from "ordinary" instruction usually carried on in the classroom? Is it worthwhile? These questions are

being asked with increasing frequency by teachers and parents all over the country.

Schramm answers the questions in part, in this way:

By programmed instruction I mean the kind of learning experience in which a "program" takes the place of a tutor for the student, and leads him through a set of specified behaviors designed and sequenced to make it more probable that he will behave in a given desired way in the future—in other words, that he will learn what the program is designed to teach him. Sometimes the program is housed in a "teaching machine" or in a "programmed textbook." If so, the machine or book is little more than a case to hold the program. The program is the important thing about programmed instruction. It is usually a series of items, questions, or statements to each of which, in order, the student is asked to make a response. His response may be to fill in a word left blank, to answer a question, to select one of a series of multiple-choice answers, to indicate agreement or disagreement, or to solve a problem and record the answer. As soon as he has responded to an item, he is permitted to see the correct response so that he can tell immediately whether his response has been the right one. But the items are so skillfully written and the steps are so small between them that the student practices mostly correct responses rather than errors, and the sequence of items is so skillfully arranged to take the student from responses he already knows, through new responses he is able to make because of the other responses he knows, to the final responses, the new knowledge it is intended that he should command.⁵

Although a whole range of learning theory positions have been reflected in programmed instruction to date, there is little question that the movement has thus far been dominated by the Skinnerian operant conditioning theory for learning. The principles underlying the construction of programmed learning sequences, and the development of these techniques, are the heart of the application of learning theory

to programmed teaching. The essential task involved is to evoke specific forms of behavior from the student and through appropriate reinforcement bring them under the control of subject-matter stimuli. As a student goes through a learning program, certain of his responses must be strengthened and shaped from initial unskilled behavior to subject-matter competence. Programming principles are concerned with how one goes about this. 6

Defining the desired behavior

A first step in programming is the specification of terminal behavior. This means that the programmer must outline precisely the behavior he wants the student to perform at the end of the program and must specify the kinds of stimulus material that the student will have available in the course of the performance. A primary purpose of instruction is to provide the student with a behavioral repertoire called knowledge of the subject matter. If that repertoire is elementary physics then the problem is to take the student there, beginning with whatever initial repertoire he possesses which even vaguely approximates the desired terminal behavior. Finding the best way to state the terminal behavior that is to be taught, in order to facilitate program preparation, is indeed an important problem in programming instructional material.

Reinforcement

A central process for the acquisition of behavior is reinforcement. Behavior is acquired as result of a contingent relationship between the response of an organism and a consequent event. In order for these contingencies of reinforcement to be effective, certain conditions must be met. Reinforcement must follow the occurrence of the behavior being taught. If this is not the case, different and perhaps unwarranted behavior will be learned. In addition, a sufficient number of reinforcements must be given so that the desired behavior is strengthened and its probability of occurrence for a particular student is high in appropriate situations.

In most instructional programs, the reinforcing agent for the students is "knowledge of results", that is, knowledge about whether or not the response he performs is the result considered correct. Failure to provide adequate reinforcement and hence failure to strengthen the behavior of the student with respect to the subject matter often results in the student showing a lack of interest. This means that his interest is shifted to other activities for which sufficient reinforcement is provided. 7

**Gradual progression**

In getting the student from his initial repertoire to the terminal repertoire it has been indicated that an important principle is that of gradual progression. The programmer does not wait for the student to emit complex behavior in the course of trial and error and then reinforce correct performance. In fact, the student may never emit the skillful behavior required. When developing complex performance, any available behavior which is the slightest approximation to the terminal behavior is first reinforced. Later this behavior is used in the next step to reinforce a small change which is in the direction of the terminal repertoire. The program moves in very finely graded steps, working from simple to higher and higher levels of complexity.

The principle of gradual progression serves to make the student correct as often as possible and is also the fastest way to develop a complex repertoire. It is difficult to see how complex behavior can appear except through the specific reinforcement of members of a graded series. It seems that this is an important principle in the rapid creation of new patterns of behavior.

At each step, the programmer must ask what behavior must a student have before he can take this step. He must ask what principles or interverbal relationships will facilitate the sequence of steps that form a progression from initially assumed knowledge to the specified final repertoire. No step should be encountered before the student
can take it with a high probability of success.\textsuperscript{8}

\textbf{Emitted behavior and prompting}

Prompting concerns making the desired behavior more probable. A student is assumed to possess some initial related behavior in a subject matter before he starts a course. The behavior available must be specified and the programmer can, at the beginning, appeal only to these available responses. How then do we get the student to emit new responses? Before behavior is reinforced it must be emitted, and instructional material must be designed to elicit the correct and appropriate behavior which then can be appropriately reinforced. A major concern of programming is with techniques for getting the student to emit new or low-strength responses with a minimum of errors.

The occurrence of behavior in a program is made more probable if the materials are designed so that each frame makes the correct answer in the next frame more likely. The probability of success is increased by the use of formal hinting and coaching techniques based upon what we know about verbal behavior. For example, a series of items can be designed so that a new work, never before used, is made more likely to occur. The German word "Fabrik" in response to the word factory is made more probable by a preceding item mentioning a colored fabric. An important factor, then, in working through a program progression, in controlling error, in evoking behavior, and

\textsuperscript{8}Ibid., 14.
in bringing this behavior under the control of new stimuli, is the use of prompting and cueing techniques. However, it must be remembered that one of the objectives of programming is to make these techniques as explicit and as non-intuitive as possible.  

Fading and vanishing

Thus far it has been indicated that programming techniques utilize the principles of reinforcement, progression, and prompting. Next is the principle of fading or vanishing. This principle involves the gradual removal of prompts or cues, so that by the time the student has completed the lesson, he is responding only to the stimulus material which he will actually have available when he performs the "real task." He is on his own, so to speak, and learning crutches have been eliminated. Fading can then be defined as the gradual withdrawal of stimulus support. The systematic progression of programmed learning is well set up to accomplish this. It is always to be kept in mind that these principles are quite in contrast to "rote learning" or drill. In rote learning, many wrong responses are permitted to occur, and the student eventually learns to develop his own prompts often to a relatively unrelated series of stimuli. Programmed learning, on the other hand, is designed to take advantage of the inherent organization

of the subject matter and of the behavior of the subject in relation to the subject matter in shaping up the student's learning. 10

Encouraging concentration

The immediate confirmation supplied in a programmed instructional sequence encourages a more careful reading of a programmed material than is the case in studying a text where the sequences of attention or inattention are so long deferred that they may have little effect on reading skills. Observing or attending behavior is efficiently shaped by the contingencies of the program. When immediate reinforcement is forthcoming, it appears that a student will be more likely to learn how to concentrate on specific features of a presentation. This is to say that the constant application to the subject matter which a program demands may not permit the development of competing habits of susceptibility to distraction; less controlled methods of teaching, however, may allow such behavior to occur more frequently. 11

Repetition for practice and review

In the course of a program progression, the programmer must build in the amount of review and repetition necessary to maintain pre-


11Ibid., 4.
vious learning and to maintain already-learned concepts which need to be strengthened and utilized in further learning. Sufficient practice and overlapping is necessary so that early material is thoroughly mastered before or while new material is introduced. In certain program sequences the steps may become larger as the student learns more and more. Also with fading and the drop-out of lessons already mastered, a systematic transition can be made from old to new concepts with a sufficient amount of review and repetition. Concepts not otherwise involved in a particular sequence of items can be reviewed periodically. Review materials can be seeded at various points in a program in order to insure the maintenance of learning.\textsuperscript{12}

\textbf{Ensuring understanding}

Another major principle in program learning is that after certain materials have been mastered, the student should use them in varied contexts. For example, a student cannot be presumed to have a thorough mastery of the concept "noun" until he has worked with material that requires him to distinguish between nouns and verbs. This kind of discrimination is related to concept formation. The progression in a programmed learning sequence can provide a well-organized sequence of examples by which the student is led to develop

abstractions and rather complicated concepts. The important goal is to enrich the student's understanding by making him permute and recombine the elements of his behavior. 13

The programmer or a good instructor is really not concerned with the student's response to any one situation. He is concerned with this only as a sample of an abstraction. The goal is not for the student to acquire a uniform and explicit verbal repertoire about the concept, but rather to acquire a repertoire which is applicable in a variety of situations. Thus he can use the concept to solve problems. He can describe the concept to others, modify it for specific purposes, build a model of it, and so forth. When he can do this, it can be said that he understands a concept. The characteristics of this response are learned not because the same form of response recurs again and again, but rather because it grows under programmed variation.

Editing and revision

A most important aspect of a programmed learning sequence is that it provides constant feedback about its effectiveness. 14 If a student does not learn, the fault lies with the program and attempts are made to modify it. The editing and revision of instructional material now becomes a very empirical matter in which the teacher or pro-


14 Lysaught, "Programmed Instruction," pp. 120-122.
grammer learns from the behavior of the learner. Each successive revision of a programmed learning sequence helps to insure that the student's performance is brought closer and closer to the defined terminal behavior, i.e., the educational objectives of the program.

Subject matter characteristics

A consideration in programming is the interaction of the characteristics of the different subject matters with the characteristics of programmed learning sequences required to teach them. Certain subjects like mathematics, and some of the sciences seem well organized for the preparation of programmed learning sequences. Other subject matters such as history, social studies, and others, have characteristics for programmed learning which can make their sequences quite different. The organization of subject matters and the structure of a body of knowledge as it interacts with teaching of that knowledge is an important ramification involved here. The notion has been expressed by programmers that interaction between the structure of the teaching process through attempts at programmed learning and the structure of knowledge of a particular subject matter may well result in revised knowledge structures.

Individual differences

Programmed learning recognizes individual differences by beginning where the student is and by permitting him to proceed at his
Students in a school system enter with different backgrounds and with various behavioral histories, and the question arises concerning the influence of these differences upon programmed learning procedures. It is probable that the effectiveness of certain kinds of learning sequences will interact with the existing behavioral repertoire of the student, and by existing behavioral repertoire is meant his achievement level, aptitude patterns, etc. It is of interest to investigate the differential effectiveness of various types of programmed sequences with students having difference characteristics. However, with the use of programmed learning the effect of student heterogeneity on teaching practices should change. Student differences would show up at the beginning of a course of instruction and can be reduced by preparatory programs which bring the students up to the achievement level required to enter the course. Further, since a student can work individually on certain subject matter, the classroom as the teaching entity can be appropriately modified.

Programmed learning does, indeed, hold great promise as an instructional technique, but the field is still too new and too fluid to even begin to specify its parameters. Although agreement is general on the principles and characteristics of programmed learning, there is

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certainly no unanimity on how they should be applied in actual pro-
gramming. 16

Programming Techniques

At the present time there are a great many uncertainties as to
what is the best way to go about the job of programming. The pro-
grammer must learn to adopt a paradigm—or model—to be followed
scrupulously as he constructs his program. The programming para-
digm supplies the basic conceptual framework through which the in-
dividual items are connected. It is essential, therefore, that it be
chosen in relation to the selection criteria, assumptions, and ob-
jectives.

There are many models from which to choose. They range from
the entirely linear—or extrinsic—program at one extreme to a full
branching—or intrinsic—program at the other. 17

Basic linear theory and technique

The learning model used in linear programming is basically a con-
ditioning model. Briefly, it postulates that a desired change in behav-
ior, defined as learning, can best be brought about by inducing and
then rewarding the desired behavior. Professor B. F. Skinner of
Harvard University is the advocate of this system. At present, this

16Philip Lewis, "Programmed Learning: An Assessment in
is the most popular approach and the simplest design widely used in available programming.

The linear materials are designed to cause the student to emit the behaviors defined as the subject matter to be learned, piece by piece, rewarding each instance wherein the student emits the desired behavior. Following a very short presentation of new material, the student is required to emit a response, usually the writing of a word. He then compares his response to the correct response (which he discovers by appropriate manipulation of the materials, such as turning to the next page), and, if his response matches the correct response, he feels thereby rewarded, and the act is thus learned.

In linear programming, the student's response is considered an integral part of the learning process; the response is induced in order that it may be rewarded and learning thus occurs. 18

Linear programs make no explicit provisions for errors by the student, since errors are, by linear theory, simply irrelevant to the process of learning. If a student makes an error, i.e., emits the wrong response, the program has at best wasted his time, at worst he may harmfully have practiced the incorrect response. Hence, linear programs, if properly constructed, are refined to the point

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where errors occur very infrequently, and may be neglected. The task of a linear program is to get the student to emit, in response to the given stimuli, the responses that have been defined as constituting the behavior to be learned. An error on the part of a student is considered a fault on the part of the program. In other words, the response is not a test to determine whether learning has taken place, but is an essential part of the learning itself. A corollary assumption is that responses made overtly—by constructing them in writing—more effectively assure the occurrence of learning. 19

The basic intrinsic program technique

Intrinsic programming makes no assumptions about the nature of the learning process that have not been common educational coin for some time. Known familiarly as the branching form of program construction, intrinsic programming is not a theory about how education should be conducted. It is a technique for preparing written materials that will accommodate quite a range of educational purposes.

Dr. Norman Crowder of U. S. Industries developed this program from his experiences over several years in training armed forces personnel to understand and use complex electronics equipment. Crowder explained his basic approach in this way:

The student is given the material to be learned in small logical units; immediately after he has read and digested one of these

units, he is given the material to be learned in small logical units; immediately after he has read and digested one of these units, he is given a short test on it; the results of the test are used to determine what next unit of information shall be presented to the student. For instance, the student's response to a test item might indicate that he has understood the lesson unit thoroughly and is ready to go to the next piece of information. On the other hand, his test response may indicate that he does not understand the information he has just studied, or it may show that he has understood the lesson material only partially. In either case, he would be directed through the medium of the program to the next appropriate bit of information—to restate the lesson, or to clarify a point that he has misunderstood, or to return to the previous unit of material and work through again. 20

The basic intrinsic programming technique, then, amounts to nothing more than the inclusion of multiple-choice questions in relatively conventional expository text and the use of these questions to continually check the student's progress through the material and to furnish specific remedial material as it is required. 21 In intrinsic programming the questions serve primarily a diagnostic purpose, and the basis of the technique is the fact that the diagnosis so made can be promptly utilized to furnish specific remedial material to the student.

**Basic differences.** Linear and intrinsic programming, while having some superficial similarities, are basically different in approach, intention, and rationale. One of the most apparent differences is that the intrinsic program involves multiple-choice responses


21 *Ibid.*, 290
while most extrinsic, or linear, programs rely on constructed responses by the student. In itself, this is not as great a difference as it may seem. Linear programs can make use of multiple-choice response and do in sequences involving stimulus discrimination—and even in such items as will or will not, larger than or smaller than, to which the student must respond by selecting the assertion that best completes the program step. Correspondingly, intrinsic test questions can demand a constructed response—prior to the selection of the alternative. For example: Q: \(4.23 \times 8.14 =\)

(a) 34.44  (b) 34.43  (c) 34.34

A student would have to multiply the numbers completely before he could make anything but a wild guess. 22

Another difference between the two general programming models is this: in most cases, students using linear programs will proceed to a subsequent item regardless of the correctness or incorrectness of their response; in intrinsic programs, the student will be directed to diverse items as a result of the correctness or incorrectness of his response.

This manner of handling student responses cuts to the heart of the difference between extrinsic and intrinsic programming. Linear programs are designed to utilize the student response as an integral part of the learning sequences, and do not provide for learning from

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22Lysaught, "Programmed Instruction," p. 86.
the program without the active response and its consequent reinforcement. In intrinsic programming, a different assumption prevails. Here it is assumed that the student will learn material from the program because it is carefully broken down into logically ordered steps. Student response, therefore, primarily becomes a diagnostic tool rather than a learning device. The response indicates the completeness and accuracy of the student's covert learning.23

Until recently there was much controversy concerning the choice of the linear or branching approach. At present, some programmers see merit in hybrid combinations of the two, depending upon the requirements of the particular program.

In addition, other programming techniques are evolving and attention is being given to the question of whether a response is essential for each frame that is presented, and when a covert response may be just as effective as an overt reaction.24 Even more important are the experiments in programming dealing with techniques that will stimulate creativity and the application of inductive and deductive reasoning on the part of the learner.

Feasibility of Programmed Instruction for the Mentally Retarded

The use of programmed instructional materials and of other auto-instructional devices has aroused considerable attention among

23Ibid., 88.

teachers who are faced with the need of administering education to large numbers of retarded students. Granted that programmed instruction can be effective and that the teacher has a definite role in making it effective, what are the student benefits from programmed instruction?

Programmed teaching methods have the advantage of laboratory precision, are versatile as a research tool, and have features which would appeal to teachers in special schools.25

Among those who value programmed instruction for the mental retardate are Capobianco, Malpass, and Price. Capobianco agrees with Blackman that the retardate can profit from a "self-instructional device made to deliver a tangible reward developmentally and culturally appropriate."26

Capobianco, in an excellent assessment of the status of programmed instruction in special education, listed its minimum essential requirements as: small steps, participation by the learner, immediate feedback, near-errorless learning and self-pacing. The regulation of learning is based on these five major principles, all of them confirmed by many laboratory studies (e.g. Green, 1962; 25 G. O. M. Leith, "Research in Programmed Learning," Special Education, LV (February, 1966), 18.

Schramm, 1962; Stolurow, 1960). These in turn are subsumed by the more general principle that the teacher knows precisely what each student should learn. This is of crucial importance for those working with retarded children, since too often these teachers have ill defined goals and presumptive methods. Principles of programmed instruction can bring both goals and methods into sharp focus. Knowledge about controlled presentation and feedback or reinforcement of programmed instruction materials can be useful to the teacher of retarded children.

**Controlled presentation**

The teacher, or programmer, must design his program so that it leads to a predetermined educational objective. The frames must be constructed so that communication to the learner is unambiguous. Every frame must be in his range of comprehension. To err on the side of repetition is better than to presume too much about the learner's state of knowledge as he progresses. Frames must be arranged in small successive steps, each logically related to the other. This reduces the probability of error and maximizes the chance of success.

In programs for retarded children, repetition is particularly important for the presentation of information and concepts. In a pilot study of a word recognition program for adolescent retardates, it was found that approximately 40 varied presentations of each word were
necessary for effective acquisition and retention. The number of repetitions will vary with the type and complexity of material to be learned, but the material must be presented in different contexts so it does not become boring.

Programmed instruction enables the teacher to emphasize major points and to exclude material that might be distracting. Since distractibility is characteristic of retarded children, the teacher's control over presentation conditions is a real asset.

Finally, controlled presentation suggests that the teacher can adapt the length of the study period for each individual (viz., Principle of Self-Pacing). Thus, programmed instruction can be adapted to the convenience of the teacher as well as for the benefit of the retarded child. These advantages are rarely available under conventional EMR classroom conditions. Programmed instruction in this way can be used to help individualize the instructional process. At the same time principles underlying the process can be exploited by the teacher for presentation of materials for which no program may be available.

Feedback

The requirement of active responding in programmed instruction insures attention to each frame as it is presented, particularly since the feedback is tied directly to the learner's response. In programmed

instruction the child is informed immediately about the correctness of his answer, whereas in most classroom situations feedback is usually delayed for some hours or even days. For retarded children, this delay is often crucial and works against retention of the material to be learned.

The advantages of programmed instruction in this respect are obvious. Immediate confirmation facilitates efficiency in learning, a basic feature of programmed instruction. The kind of feedback that is provided will depend on the type of programmed instruction that is used. A teaching machine may provide both visual and auditory signals that inform the learner whether he is correct or not. A programmed textbook, on the other hand, relies on the type of confirmation encountered already. 28

Programmed instruction and well planned programmed material, properly administered and appropriately reinforced, can enable mentally retarded children to learn in less time, retain more information over a longer period of time and have a better understanding of the subject than when instructed by conventional methods.

In summary, programmed instruction for retardates is clearly feasible. It is proving more efficient than alternative presently utilized, particularly in institutions. Work is needed on the factors

that make it most effective for learning and transfer. The method
to be used to determine the special educational requirements of the
retarded. The studies conducted thus far reveal a developing
rapprochement between the psychology of learning and educational
practice. Hopefully, programmed instruction will continue to be a
catalyst in effecting applications of the psychology of learning to
teaching activities. 29

A Brief History of Automated Teaching

The same forces which have characterized the evolution of general
educational practices are inherent in the history of the new science of
automated teaching. As a result of the expansion and multiplying com-
plexities of political, economic and social interests, there developed
an increasing need for the rapid education of large numbers of people.
New educational objectives demanded new methods of instruction, and
the history of education is marked by many diverse attempts at es-
tablishing more efficient teaching procedures. Once again teaching
methods must be re-evaluated. Rigid adherence to the principle of
personal teacher-student relationships no longer seems feasible. An
instructional system more appropriate for present-day needs must be
established. It is probable that the use of automated teaching devices
can fill this need to education.

29Lawrence M. Stolurow, "Programmed Instruction for the Mentally
Retarded," Review of Educational Research, XXXIII (February, 1963),
135.
As early as 1926, Professor S. L. Pressey of Ohio State University discovered the possibilities of automation in education. He brought out his practical notion of a "teaching machine," in his case, a rather simple device, which after a correct number of responses rewarded the student with a piece of candy. Pressey's device both taught and tested by providing immediate feedback to the learner as to whether or not he was learning what he was supposed to learn. The applied psychology of learning, in the form of machines that both taught and tested, harbored for him an "industrial revolution in education." For many years, his efforts were given little support by educators. Skinner explained this lack of progress:

Pressey's machines succumbed in part to cultural inertia; the world of education was not ready for them. Pressey was working against a background of psychological theory which had not come to grips with the learning process. The study of humor learning was dominated by the "memory drum" and similar devices originally designed to study forgetting. Rate of learning was observed, but little was done to change it.  

There is no record of any acclaim for Pressey's machine but it does bear the distinction of being the first of its kind, the progenitor of a significant movement now taking place in education. But it was not until Professor Skinner, in 1954, began to lend his prestige to the idea that general interest in the teaching machine was revived.

In 1930, Peterson devised a self-scoring, immediate feedback de-

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vice. This Chemo-Card, as this device was later called, utilized the technique of multiple choice. A special ink was used by the student in marking his answer. The mark appeared red if the answer was incorrect; a dark color resulted if the answer was correct. Although Pressey's notions and the Chemo-Card might have stimulated an interest in automated teaching techniques in the twenties, educators and researchers obviously were not at that time ready for this advanced concept of teaching. Automated teaching did not take hold.

Later Pressey devised a punchboard device and selective-review apparatus using cards. The key answer sheet inside the Punchboard contained holes opposite the correct answers only. If the answer was correct, the student's pencil penetrated deeply; if incorrect, the pencil did not penetrate the paper significantly. In addition, he developed a number of other devices and conducted many experiments with autoinstruction during the 1920s and the early 1930s but their impact on instructional technology was almost inconsequential.

Except for sporadic developments, mainly during World War II, Pressey's work was virtually forgotten until B. F. Skinner of Harvard University stimulated a new surge of interest in machine teaching. In 1954, Skinner published "The Science of Learning and the Art of Teaching," which provided the basis for the development of his teaching machines. In this article, he stressed the importance of reinforcement in teaching and suggested teaching machines as a method of providing this needed reinforcement for the learner. The article presents in
condensed form the results of more than a quarter century of research and experimentation in this field.

However, most educational leaders are demanding thorough study first and much subsequent research in school settings to ascertain the best uses of teaching machines. The leaders themselves must initiate the needed research and evaluation in their schools in order to make wise decisions.

During the last few years, researchers have been focusing their attention to investigating many of the variables which are pertinent to the design and use of teaching machines. Learning theorists are now most outspoken concerning the application of theoretical concepts to teaching machine technology. Transfer of training, mediational processes, reinforcement, motivation, conditioning, symbolic processes, and language structure are but a few of these areas of interest.31

Essentially, the history of automated teaching is short—it started in the mid-twenties and was strenuously reactivated by the appearance of Skinner's 1954 article. Empirical investigations of many important issues in this field are just now beginning to appear. However, the necessity of developing automated teaching methods has been evident for many years. The coincidental, unprecedented increases in school

enrollments, skyrocketing costs of education, expansion of knowledge, and search for practical ways to achieve quality teaching in the face of such developments provide fertile ground in which the seed of Pressey's ideas will germinate and flourish.

Teaching Machines and the Learning Process

Coming as it does, out of the psychological laboratory, the teaching machine is also more than mildly interesting to psychologists. It represents a promising application of a widely accepted principle of learning, namely immediate and unequivocal reinforcement. It is of interest to educators because of its potential use as an efficient aid to teaching. It holds the possibility of speeding up certain kinds of learning, thus making teaching more efficient and less demanding in terms of teaching time and effort. The result may be to aid materially in stretching out available teaching resources and in relieving the present and almost surely continuing shortage of qualified teachers.32

Educational automation was recently rediscovered by B. F. Skinner. His ideas have been significant and have contributed to the management of the learning process, particularly through the manipulation of reinforcement. Skinner has pioneered the programming of materials for teaching machines and has generated much of the

current interest. Some feel he has started a new movement which could have rather profound effects on the teaching profession, school design, and our whole concept of education. The machine programs he devised incorporated improvements which not only measured information but provided the learner with a developmental sequence of judgments arranged in logical order. The material to be learned is presented to the student, one "frame" at a time, in a small window on the face of the machine. The student writes his response on a section of paper in a slot near this window. He then moves a lever, thus exposing the correct response, and compares this with his written response. If his answer is correct, he brings the next frame into view and repeats the process. If the response is incorrect, the question is automatically "marked"; it reappears later to give the learner a chance to correct and learn. Skinner describes the characteristics of his machine program as follows:

1. There is a constant interchange between the programmed materials and the student. Unlike lectures, textbooks, and the usual audio-visual aids, the machine induces sustained activity. The student is always alert and busy.
2. Like a good tutor, the machine insists that a given point be thoroughly understood, either frame by frame or step by step, before the student moves on. Lectures, textbooks, and their mechanized equivalents, on the other hand, proceed without making sure that the student understands and easily leave him behind.
3. Like a good tutor, the machine presents just that material for which the student is ready. It asks him to take only that step which he is at the moment best equipped and most likely to take.
4. Like a skillful tutor, the machine helps the student to come up with the right answer. It does this in part through the orderly construction of the programmed information and in part with techniques of hinting, prompting, suggesting and so on, derived from an analysis of verbal behavior.
5. The machine, like a private tutor, reinforces the student for every correct response, using this immediate feedback not only to shape his behavior most efficiently but to maintain it in strength in a manner which the layman would describe as "holding the student's interest."33

The teaching machine is based upon three widely discussed conditions of learning--operant conditioning, contiguity and repetition.

Pavlov demonstrated that hungry or thirsty animals, under control of the experimenter, could be conditioned to make a response to a new stimulus that previously had not elicited the response. Skinner bypassed this traditional approach to conditioning and proposed operant or response conditioning. He demonstrated that hungry or thirsty animals, under the control of the experimenter, could be conditioned to make a specific response or a series of responses rapidly when rewarded by the experimenter directly or by a mechanical arrangement. His ideas concerning conditioning have resulted in dramatic improvement in training animals and have led directly to the recent high interest in machine instruction in the schools.

How does "operant conditioning" apply to the human learner? The reinforcing stimulus, Skinner argues, is the reward of receiving immediate knowledge of a correct response. It is alleged that operant conditioning is applicable not only to the laboratory rat or pigeon, but to the human learner as well:

Oddly enough, when one compares the behavior of organisms such as pigeons and rats under otherwise identical conditions of instruc-

tion, one finds that the behavior of these differing species are essentially alike. 34

There is a difference in complexity between the behavior of the laboratory animal and that of the student solving a problem in differential equations. There is no essential difference between the two organisms in the processes by which their behaviors are established. 35

Since the teaching machines are based on the principle of telling the learner at once whether he is right or wrong, their utility will of necessity be limited to material where there is a right answer. Structured information, concepts, relationships, associations, differentiations, abstractions, identification of key elements—all these are of such a nature that they can be put into programs calling for a series of "correct" responses. Much school learning is of this kind. But much of it is not—for example, where value judgments must be made. Sometimes the most important thing for a pupil to learn is that there are not any pat answers. Unfortunately, few personal, social, economic or political problems that are met in everyday living tend to be clear, simple, or categorical. Furthermore the more crucial and far-reaching outcomes of learning will always be found at the level of interpretation, application, appreciation and invention. These levels are still outside the reach of most self-learning devices and thereby place a low ceiling on what is to be mastered. 36

34 Ibid., 975
A machine can provide informational background, but beyond this, where intelligent opinion can differ, it can only help identify what the alternatives are. It cannot ask any questions to which original, different answers are equally correct. It cannot ask "what do you think and why" questions. Nor can it ask questions that need more than a few words to answer. Questions whose answers require a complex formulation by the learner would have to come outside the scope of the teaching machine.

The kind of learning that can come out of an experience is limited by the quality of that experience. For motor learning, you need motor experience, for emotional and social learning, you need emotional and social experience. The learning possible from teaching machines will be limited to the learning that can come through the experience of reading (or perhaps listening to) a series of items and answering a question after each one. This well limits the content to visual (or auditory) and ideational learning. Motor skills, social skills and attitudes could probably not be efficiently taught by machines, though the relevant information needed for them could be. Habits of independent study, skills of democratic leadership and membership, and originality would probably not be suitable "content" for programming for a teaching machine, although some of its advocates see it as a key device in enhancing pupil creativity.

Where teaching machines or other devices for using "programmed" material are used, teachers will still have to design or help design the
programs, for it is they who know the steps by which the ideas in the field they teach can be grasped by students. In a given subject, some students will need much easier programs than others, and it will be the teacher's responsibility to match programs with students. It is anticipated that the machines will make some types of pupil learning more efficient and that they will permit teachers to devote less time to mechanical tasks and more to bringing out meanings and applications of new material. In a number of cases, for example, teachers have found that if students have gone through a machine sequence that covered basic concepts and terminology, then class lectures and discussions could go much farther than would otherwise have been possible. The students' mistakes on the machine have also given the teacher precise information as to where students still needed help (Galanter, 1959; Lumsdaine and Glaser, 1960). As teachers find ways in which teaching machines can help them meet some of their objectives, it will be especially important for them to continue to make other provisions for meeting objectives not amenable to this approach. 37

It seems reasonable to assume that as experimentation with teaching machines continues, the reading load will be decreased, a wider variety of learning experiences will be included, and other than the reinforcement of learning theory will be used in programming.

The continuing research in this field will explore the effect of the intelligence of the learners. Related questions are also likely to be investigated, particularly those which concern the effect of teaching machines on the creativity of students, the transfer of learning, the relationship between this means of instruction and maturity level, and the possibility of boredom.

The use of teaching machine programs presents new responsibilities for pupils and teachers. The teacher should be alert to the information about this development, and to machines and materials now being developed. He should encourage his pupils to understand better the self-initiating activities which use of the machines will call for. Indeed, the more man advances in the realm of automation, the more need there will be for intelligent human beings to deal with the issues by this same automation. 38

Automation in Special Education

Certainly these are the years wherein added research and new methods in instruction are more common in our schools than at any former time in history. The tremendous increase of knowledge and the development and application of technology commonly spoken of as the hardware and software of education are having an important impact upon teaching and learning. It is becoming increasingly obvious to

educators that many traditional methods of education are inadequate
to cope with present quantitative and qualitative requirements for
instruction, and nowhere in the public education system is there a
stronger need for greater efficiency and quality of instruction than in
programs for the mentally retarded. This is true primarily because
so much must be taught so well in so little time, for the majority of
the retarded probably will continue to leave special class programs
at or near sixteen years of age. In addition, the physical and psycho-
logic aberrations that can interfere with learning are probably far
more numerous than in a regular grade class; therefore grouping for
efficient instruction is quite often not feasible or is at best a crude
compromise. 39

Advances in educational technology in recent years have been ex-
citing--new use of open and closed circuit television, "single con-
cept" and programmed films, nonverbal films and films that motivate,
automated electric talking typewriters, computer assisted instruction,
teaching machines, and so forth--but the incorporation of many of
these innovations in school programs for retarded children has moved
at a snail's pace. Part of this lag undoubtedly can be attributed to the
understandable reluctance of some administrators to adopt sometimes
expensive methods and equipment that have not been properly investi-
gated and evaluated. Much of the lag can be accounted for by pessi-

39Irving Philips, Prevention and Treatment of Mental Retardation
mistic attitudes concerning the capacities of the retarded, lack of imaginative thinking, and a general inertia traceable to a multiplicity of factors.

To argue that teaching machines are not appropriate for the mentally retarded is to ignore what has happened in special education over the years—we have been using modified forms of teaching machines and have been programming. As evidence of this statement, it is merely necessary to reflect upon the use of flash card games, film strips, worksheets, and other techniques and devices which are part of everyday instruction. 40

In reply to critics who feel that automated instruction will take the "human element," presumably more crucial to the retarded even than to the nonretarded, out of teaching, advocates of increased use of the new technology in special classes have some strong rejoinders. They point out that what we label "human element" is a double-edged sword not always having a salutary effect on retarded children. Prejudice, ridicule, sarcasm, irritation, and impatience will not be exhibited by an automated device. In certain situations, shy or distractible children may be better taught in the absence of others, including the teacher whose presence, when the pupil makes errors, may serve only to inhibit or hinder learning. Automated devices also

can control certain critical time intervals in instruction more precisely; for example, they can provide immediate rather than delayed reinforcement. More accurate standardization in the administration of various formal and informal educational tests also can be achieved.  

Retardates, as a group, have special requirements that might be better met by self-instructional devices than by other classroom methods. First, retardates are known to make slow progress in a classroom situation, placing enormous time and temperament demands upon the teacher. An immediate feedback device is infinitely patient, extremely motivating and can be programmed to move very slowly through new materials.

Second, for most educable mentally retarded children, there is a history, due to poor achievement, of receiving little or no reward in school setting prior to their placement in special class programs. In addition, the usual rewards for good performance in school are likely to mean little to the educable child from a culturally or economically impoverished background. A self-instructional device, however, can be made to deliver a tangible reward, developmentally and culturally appropriate, whenever the subject makes a correct response. A further advantage is that the machine furnishes an impersonal environment that is not likely to arouse anxieties associated with past teacher-pupil relationships.

Third, the multiplicity of causes of mental retardation results, 

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41 Philips, Mental Retardation, p. 270.
both in theory and practice, in a highly heterogeneous group. Self-instructional devices make allowances for individual differences by permitting students to proceed at their own pace.

Fourth, by the very nature of intellectual deficit, a retardate's incidental learning from everyday experiences is frequently much poorer than the environment demands. For this reason, retardates must be trained more extensively and to a higher level of mastery. Self-instructional devices facilitate both aims. In particular, these devices make it possible to specify, in terms of overlearning, the degree of mastery achieved.

Fifth, the highly controlled teaching environment made possible by a teaching machine provides the opportunity to examine school materials carefully from the point of view of maximally efficient displays and the psychological skills related to their mastery.

With the development of a new and more sophisticated educational technology, significant benefits can be brought to the retarded as well as to other exceptional children, but special educators can and should be leaders, not followers in exploiting the full range of these benefits. The substantial gains already made through research and development efforts with teaching machines argue forcefully for the real and substantial contributions of this technology to the future of special education. 42

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REVIEW OF RELATED LITERATURE

While the literature on the use of programmed instruction with normal subjects has grown at an exponential rate, research carried out in the area of programmed instruction with the retarded is not extensive and in many cases the studies lack methodological sophistication. The studies range from controlled experiments to anecdotal accounts of behavioral changes which resulted when programmed instruction techniques were used. They exist in the form of unpublished papers and theses, progress reports, or references in secondary sources. Some have been carefully executed and reported. Others exhibit definite flaws; for example, adequate pretests and posttests were not administered, or the report itself contains discrepancies or omissions which make interpretation of the findings difficult.

The present review attempts to evaluate a few of the research projects carried out so far and to indicate some probable direction that future research can be expected to take. Two principal types of studies have been identified: (1) studies comparing programmed instruction for the mentally retarded with conventional teaching techniques; and (2) studies utilizing programmed instruction in special classes.
Studies Comparing Programmed Instruction for the Mentally Retarded with Conventional Teaching Techniques

In view of the language problems that mentally retarded children have, it is not surprising that programmed instruction reading has been a popular topic for research. In spite of decades of research on reading, its nature is not well understood. Hopefully, programmed instruction will contribute to one's understanding of the learning processes in reading. To date, programmed instruction studies have dealt with specific aspects of the total process rather than with all aspects at once. This is typical, since programmed instruction research is highly specific. It therefore remains for future work to extend these interesting and promising beginnings to other facets of reading.

An extended project in which both reading and arithmetic materials were programmed was reported by Blackman, Capobianco, Hoats, East, Forcina, Shepherd, and Saxton in 1964. The objectives of the study were: (1) the development of an automated instructional device for presenting the two kinds of material; (2) construction of programs; and (3) the comparison of achievement and behavior changes in retardates taught the material by machine and by

a "traditional" classroom technique. The project covered 3 years, of which 18 months were devoted to the development of the apparatus and to methodological research on program writing, 6 months to program construction and 1 year to evaluation.

**Word skills**

In the Blackman, et al reading program, 20 units or 218 sub-programs were constructed covering 311 reading words. The program was designed to take the student from single-word matching to the point where he answered questions based upon stories containing the programmed words. Because the Ss progressed more slowly than anticipated, however, only 55 of the 218 programs had been covered by the end of the study.

Subjects were 36 institutionalized retardates. Half were assigned to the teaching machine condition and half to the control condition. Subjects in the latter group covered exactly the same material and maintained approximately the same pace as the experimental Ss, and the teachers who taught them also served as experimenters for the machine group.

Performance of both the experimental and control Ss, as measured by two standard achievement tests and a special test designed to assess achievement on the programmed material, improved to a statistically significant extent over the course of the study. There were, however, no reliable differences between the two groups on any
of the achievement scales. The relative unsophistication of the programs used and the limited time taken to evaluate and review these programs are suggested possible reasons for this negative finding.

In 1963 a study was designed by Scott to teach word recognition skills to 14 adolescent retardates attending an intermediate school in New Zealand. The S was shown a series of word pairs on a teaching machine. As soon as a pair appeared, one of the words was repeated over earphones from a tape recorder. The task was to push a button above the word that had been named. Following a correct choice, a color slide illustrating the word appeared on the screen. Following an incorrect choice, the word pair disappeared. Seven control Ss were taught to discriminate between the same words by conventional methods. At the time the survey was published, only preliminary results were available. These indicate that the machine group had gained an average of 20 sight words as compared with a gain of 4 or 5 words for the control Ss.

Two comparison studies were carried out by Ellson in 1962.

In the first, 48 retarded Ss were given six sessions of reading in-


45D. G. Ellson, T. L. Engle, L. Barber, and L. Kempwerth, "Programmed Teaching of Elementary Reading" (unpublished manuscript) Indiana University, 1962.
struction under either a programmed instruction condition, a standard classroom condition, or a procedure in which programmed instruction and classroom sessions were alternated. A fourth group of 16 Ss received no instruction.

The pre-test to post-test vocabulary gains were as follows: 32.9 (programmed instruction group), 18.1 (classroom), 37.6 (alternation), and 6.6 (control). Intergroup comparisons showed both the programmed instruction and alternation groups to have acquired significantly more words than the control group, and the alternation Ss to have acquired significantly more than the classroom Ss.

The second study extended the preceding one by six sessions. Subjects in the programmed instruction group were given the additional training under the classroom procedure, while Ss in the classroom group were trained under the programmed instruction procedure. The conditions for the alternation and control Ss remained the same.

The mean gains for the four groups, respectively, were 39.0, 37.6, 57.2, and 12.6. The report does not make clear, however, whether these gains were made from the beginning to the end of the study as a whole, or only during the second half. Gains made by the three experimental groups are reported to be significantly greater than those made by the control group.

Malpass found automated instruction superior to conventional
classroom teaching. 46 This was true for both public school and institutionalized educable mentally retarded children. The study dealt with acquisition and retention of word recognition, reading and spelling skills. Individual words were learned first; then they were presented in phrases and sentences. Finally, subjects were required to read a paragraph composed of words taught in the program. Acquisition rates varied extensively, with retardates in the 65 to 70 IQ range showing most progress. Probably the most striking finding of this study was that retention rates were very high. Practically all of the subjects taught by programmed instruction retained from 75 to 92 per cent of their post-program knowledge three months later. Some children retained their gains two years after completing the program.

These results were confirmed in part by a study by Lawson and Watson. 47 They found that a group of institutionalized mentally retarded children retained approximately 85 per cent of the new words they learned from teaching machines over a three month period. Such results underscore the potential value of programmed instruction and give some answers to questions about effectiveness of teaching machines


versus conventional techniques for retarded children.

Fewer programs exist for teaching simple number skills to retarded children than word skill programs. From available studies, however, there is little doubt that programmed instruction can help retardates to learn basic arithmetic processes and concepts, particularly addition and subtraction.

Number skills

Merachnik and Quattlebaum briefly reported a study in which five retarded adolescents were given programmed instruction in addition, subtraction, multiplication, and division over a 6-month period. A published program was used and the material was presented on a manually operated teaching machine.

Five control Ss received instruction on the same material in small groups which made use of individual workbooks and teacher lecture presentations.

At the end of the study, both groups showed some gains in arithmetic computation and arithmetic reasoning as measured by the Metropolitan Achievement Test and in arithmetic grade score as measured by the Wide Range Test. They did not, however, differ significantly from each other on any of these measures. With so few Ss, an individual analysis of results would appear to have been more

appropriate and informative than the group-comparison measures used.

The purpose of a project by Sprague and Binder in 1962\textsuperscript{49} were (1) the development of an automatic device to be used in programming arithmetic; and (2) the determination of the relative efficiency of this method of teaching as compared to a conventional classroom procedure.

The apparatus was a fully automated multiple-choice device on which any two-digit addition, subtraction, or multiplication problem could be presented. The machine advanced to the next problem only when the S had made a correct response, and it provided further visual feedback concerning the correctness or incorrectness of each response made.

The programmed material consisted of 121 addition, 121 multiplication, and 66 subtraction problems. The slides containing the problems were placed in trays of 38 slides each and arranged within trays in the presumed order of difficulty. The S worked on a particular tray until he had reached a criterion of less than 25\% errors of each kind of problem and then moved on to the next tray.

Fifteen adolescent retardates served as Ss. Seven were given 12 training sessions on the programmed material. The remaining 8 were enrolled in a special class which met three times a week.

The California Achievement Test and a special test of 380 problems programmed for machine presentation were administered before and after training. No differences were found between the groups in terms of gain scores on the reasoning, addition, and subtraction sections of the California or on the programmed test problems.

As with their word-skill programs, Blackman and Smith found that retardates acquired arithmetic skills efficiently and consistently under programmed instruction. In addition they found significant differences in favor of programmed instruction over conventional classroom instruction on one arithmetic post-test, although not on two others. Retention of arithmetic skills are very high after three months. These studies confirm reports by Stolurow about effectiveness of programming instruction for teaching number skills and suggest that abstract number concepts can be learned by retarded children if presented appropriately.

Recently, Johnson conducted a study in Oregon's central Willamette Valley to examine the effectiveness of teaching methods in arithmetic for mentally retarded subjects. The sample consisted of 72 subjects in public school special classes with IQ's of 49 through 80, chronological ages of 108 through 166 months, and mental ages of 71 through

through 103 months. The sample was divided into three groups: one group studied a program designed by the investigator, another studied from a commercially developed program (TMI - Grolier's Elementary Arithmetic: Addition and Subtraction Facts), and the third group studied from teaching lessons. During the ten weeks of study, two groups alternated programmed textbook sessions with teaching lessons throughout the week. The results tended to lend credence to the premise that this curricular combination can produce substantial gains in academic achievement for the educable mentally retarded child. The retarded child appears to adapt to programmed instruction and seems to make as much or more progress through these approaches as he does through conventional teaching methods.  

Two methods of presenting programmed materials in an addition and subtraction program of instruction were investigated by Price. The 2 methods required different kinds of responses. The "Answer-Construct" method required the subject to write-in or construct an answer; the "multiple-choice" method required the pupil to select, of the available programmed answers.

Thirty-six students from a residential school for the MR were divided into 3 groups. The groups incouded a conventionally taught group and 2 machine-trained groups equated on the basis of CA, MA, and IQ. The CA range was 11-5 to 21-5; the MA range was 5-6 to 8-10;  

and the IQ range was 40 to 66.

The program was concerned with simple counting, addition, subtraction, and arithmetic signs. The linear-type program arrangement employed a fading technique.

Results of a pre-test and post-test performance indicated that all 3 groups showed significant improvement during the addition phase of the program (.05 level); the multiple-choice machine group showed significant improvement during the subtraction phase (.05) level; but there was no significant improvement for the answer-construct or conventionally taught groups on subtraction problems.

It was concluded that under the conditions this study was made, both programmed instruction and conventional teaching methods were effective in teaching elementary addition to MR students, but the multiple-choice presentation of subtraction problems was more effective than either of the other two methods. With regard to amount of time required to learn a given amount of subject matter, automated teaching methods appeared to be clearly superior to the conventional teaching method. 52

Blackman developed an arithmetic program which began with form discrimination and ended with simple division and basic fractions. Of the 175 sub-programs developed, only 54 had been presented by the end of the study.

Both the experimental (machine) and the control (classroom) Ss showed improved performance from beginning to end of the study, as measured by the Metropolitan, the Wide Range, and a special achievement test designed to cover the programmed material itself. Although there were no differences between the groups in mean scores as measured by the two standard achievement tests, on the special test the experimental Ss made significantly greater gains than the control Ss.53

Research in programmed instruction with arithmetic materials not only has indicated that the method is feasible but also has suggested that it might be more efficient than many of the alternative methods of instructing MR children.

Research Studies Utilizing Programmed Instruction in Special Classes

The results of research leave little doubt that the mentally retarded can acquire and retain basic academic skills by means of programmed instruction. In addition to word skills, programmed instruction of spelling and cursive writing have been investigated. Some psychologist-educators have even constructed total classroom environments that focus on programmed instruction.

Programmed classrooms

By their very nature, special education classrooms require somewhat different facilities, equipment, and utilization than those for normal children. Within this framework, some unique classroom plans have been suggested for optimum use of programmed instruction. Birnbrauer, Bijou, Wolf, Kidder and Tague set up a programmed classroom at the Rainier School in Buckley, Washington. The routine, classroom, and, of course, the pupils are part of a project established for the following purposes: (1) to develop materials according to the principles of programmed instruction in primary academic subjects for educable retarded children; and (2) to develop procedures whereby motivation, good study habits, cooperation, perseverance and concentration can be developed and strengthened. The classroom is subdivided into individual study cells, each equipped with a teaching machine and related materials. Programs are obtained from the teacher. After preliminary instruction, the child can fit the programs into the machines and operate them without help. The curriculum includes word drill, reading, and arithmetic.

The teacher serves a more generous purpose than program dispenser, however. She records each child's progress, supplements programmed instruction with other types (focusing on concept development rather than skill drill), and encourages attainment of
social skills through a variety of group activities.

After more than a year's experimentation with this programmed classroom, the investigators and school officials were pleased to find: (1) retarded children learned efficiently; (2) they were cooperative and well motivated; and (3) they showed improvements in school activities other than the academic skills taught by programmed instruction. 54

**Language arts**

Naumann and Woods have made a preliminary report of an automated basic spelling program for MR children. Three boys and three girls in a special education program (whose chronological age varied between 10 years, 1 month, and 16 years, 2 months, and whose Wechsler Intelligence Scale for children IQ's ranged between 59 and 74) were taught 62 words from representative spelling lists with 15 Skinner-type program units, which varied in length from 25 to 34 frames. Teaching machines were used. All children were given selected parts, including spelling, of the Gates Reading Diagnostic Tests before starting and after completing the program. All children showed some gains on the spelling tests. Observations indicated: (1) the child should always write the whole word not just the

missing part; (2) it was preferable to write programmed units in story form; (3) children responded favorably to programmed instruction; (4) machines had "play appeal"; and (5) basic training in phonics should be emphasized in pupil's readiness experiences. 55

Birnbrauer and his colleagues at the Rainier, Washington, State School also have reported remarkable word-acquisition rates by retarded children. They found some moderately retarded children can assimilate up to six new words per learning session, under both multiple-choice and constructed response modes of programmed instruction. Birnbrauer's team developed a phonics program to accompany sight-vocabulary presentation and used trinkets, gold stars and other tangible rewards to motivate children initially. A later report suggests that even though the motivational effects of such reinforcements may wear off, as with normal children, high word-acquisition rates can be expected from exposure to programmed instruction.

The experimental use of a teaching machine designed for mentally retarded children in a teaching experiment at Coleshill Hospital, Birmingham, England, showed that the use of such a machine was feasible for teaching the Social Sight Vocabulary. In a small experiment adult patients with a mean age of 24 years, who were com-

pletely illiterate and whose IQ's ranged from 46-58, were taught the social sight vocabulary via the teaching machine. Pupils were instructed in 15 half-hour sessions and it was found that the average number of words learned during that time was 12 per person ranging from 8-19 words. It was concluded that it was possible to teach mentally retarded to recognize words of the social sight vocabulary by use of teaching machines but that probably better results could be obtained by improving the program itself.

Hewett, Mayhew, and Rabb described a 1-year experimental program designed to teach a 250-word basic sight vocabulary to 25 mentally retarded or severely disturbed children. The children had been enrolled in the program for periods of from 3 months to a year and they attended reading sessions three times a week.

The words from a set of pre-primers and a primer were programmed and presented by means of manually operated teaching machine. At each session the child worked with both the machine and the book.

As yet, only preliminary data are available but these indicate that a program is successful in bringing non-reading exceptional children up to first grade reading level.

Delinquent adolescent retardates were given daily reading instruction by Fernandes in a programmed learning classroom set up

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within a special training and rehabilitation unit. Because the boys read at different levels at the beginning of the study, it was necessary to develop several reading programs. In one of these, 46 words used in describing various hall jobs were programmed and presented on a teaching machine. Many of these words appeared on a job board which contained information about daily work assignments. Thus, the boys had frequent opportunity to use the vocabulary outside the classroom.

The author stated that nine boys who had little or no reading skills at the beginning of the study have completed this particular program. Pre-test and post-test data, however, are not cited. 57

Davy used the Woolman Progressive Choice method for teaching reading to retarded children. Although the method is not classified by Davy as a programmed instruction method, it has some features of programmed material. Essentially, the technique reduces the initial complexity of the reading task by introducing one letter at a time in an order designed to maximize discriminate ability among letters. Each new letter is combined with those previously introduced to form simple words.

Pre-test data are not reported. Seven children who participated in the program for 1 year are said to have progressed from a non-reading level to recognizing and writing most of the alphabet.

letters and to using them in forming simple words. The three children who remained in the program for 2 years progressed from "no functional reading" to reading stories appropriate to first-to-third grade normals. Information concerning an additional three children who remained in the program for less than a full year is not given.

Retention tests administered at the end of summer vacation showed the three children in the 2-year group to have retained 95%, 82%, and 58% of the 119 words taught during the preceding year. 58

Arithmetic

The lowest 50 students in arithmetic ability from a second grade Tokyo elementary school were given programmed instruction in addition and multiplication in a study by Takeuchi. 59 The material, presented in book form, was reported to have been programmed according to Skinnerian principles. A "high degree of success on the posttest" was claimed but no actual results were given.

Smith and Quackenbush report how a portable multiple-choice device was employed in presenting elementary mathematics problems to 23 retarded adolescents over the course of one school year. The


primary purpose of the material was to provide practice in carrying out certain arithmetic operations. No pressure was placed on the students to use the machines, but they were always available for anyone who wanted to use them as a supplement to regular classroom instruction. Over the course of the year some students completed several hundred problems, while others completed only a few.

The problems were presented, eight per page, in a workbook which rested on the top of the device. There were three possible answers for each problem, and the student depressed a button adjacent to the answer selected. A buzzer or a green light signaled that a choice was correct. No information was given following an incorrect choice.

Over the course of the year students given this additional practice gained .51 of a grade level in arithmetic on the California Achievement Test. Gains in reading and in language, in which the students received no supplementary practice, were .25 and .24 respectively. For control purposes, these gains were compared to those made by 34 students in the previous year when the devices had not been available. For this group the gains were .19 in arithmetic, .26 in reading, and .24 in language.

It is regrettable that the authors, rather than simply presenting a pooled gain score for the group as a whole, did not include information about the progress of Ss who had taken full advantage of the
machine's availability, and of $S_6$ who had not. 60

Bradley and Hundziak made an exploratory investigation concerning the employment of a teaching machine for teaching time to mentally retarded subjects in a residential school setting. The purpose of the investigation was: (1) to determine whether the TMI - Grolier Time Telling Program published for normal children is useful for mentally retarded subjects; and (2) to ascertain possible applications of the procedures for retarded subjects. The experimental design was pre-test training and post-test. Results indicated an increase in gain scores which ranged from two to 11 on the post-test for all subjects. Little relationship was evident between the gain scores on time telling and achievement of IQ. The findings suggested that mentally retarded subjects can profit from a teaching machine program written for normal children. The primary advantage seemed to be in rapid determination of problems involved in learning the task. Perceptual ability may be a factor in successful performance of subjects. 61


SUMMARY

To assess the effectiveness of programmed instruction is difficult because most studies are characterized by poor experimental design, unsuitable programs, inefficient control of variables and inadequate evaluative criteria. However, though programmed instruction is not superior to conventional teaching in all respects, children taught by the former method learn in less time, retain more information over a longer period of time and have a better understanding of the subject than those instructed by conventional methods.

The bulk of research on programmed instruction with retardates, to date, fails to establish the superiority of programmed instruction due chiefly to: (1) poor quality of programs, (2) inadequate field testing and revisions of programs, and (3) programming principles that are contrary to the teacher's philosophy. The issues stemming from the design and use of programmed materials are many, varied, and controversial. While the functional usefulness of commercial programs is increasing, there is yet no decrease in the necessity for both individual teacher evaluations and formal test assessments of programmed materials. It will be necessary, therefore, to include information on programmed instruction in the in-service and pre-service programs for special educators since they must have skill in
evaluating and modifying programs to suit the learning character-
istics of their pupils.

**Implications of Programmed Instruction in Special Classes**

Research with programmed instruction attests to its ability for teaching word and number skills to retarded children. Whether it is more effective than other types of instruction for these purposes is still somewhat equivocal, although several studies strongly favor it over conventional classroom teaching. Certainly it presents some clear advantages for teachers who can obtain materials and space for programmed instruction. It can reduce the drudgery of repetitious drill; it enables truly individualized instruction; children can work at their own pace; and it encourages motivation for learning.

The problems of programmed instruction for the retarded seem to be more in terms of development and dissemination of programs than in establishing the validity and utility of the method. From research reported so far, programmed instruction is likely to become an increasingly significant educational tool for helping retarded children acquire and retain skills necessary for self-subsistence in our complex society.

Certainly it cannot be implied that programmed instruction is or can be the panacea for all educational endeavors. It is encouraging to note, however, that the programmed instruction movement is not a transitory, magical, or momentary fad but is vital and growing.
One reason that programmed instruction has survived is that learning theorists and behavioral psychologists have offered a working model for efficient learning. Programmed instruction has been tested; it has been found to be effective with retarded students because the students are doing something, they are being reinforced, and they are meeting success.

Special class teachers have a direct effect on the amount pupils learn from programmed instruction; learning from these materials is not automatic. When pupils are permitted to progress at their own rates, one can look for accelerated learning. Motivation to learn is of tremendous importance; with programmed instruction the teacher's role can be maximized. The work of Birnbrauer and his colleagues indicates that the outlook for the mentally retarded can be optimistic. Unless drastically different results are obtained in regular classroom use from those observed in empirical studies, a substantial increase in academic use of programmed instruction can be expected for retarded children, to the point that teaching machines and programs may become as common as any other audio-visual device in classes for the educable mentally retarded.

Programmed Instruction and the Future

Industry and psychiatry have discovered the practical benefits of programmed instruction. Physicists, biologists, mathematicians and economists have shown a readiness to program their instruction. It
has been used by instructors in the armed forces and the prison services. It has been used in the classroom and the university. But its possible advantages with the mentally retarded have not really been explored. Programmed instruction could, as Skinner believes, "maximize the genetic endowment of each student, it could build the greatest diversity of interests, it could lead him to make the greatest contribution to the survival and development of his culture."62

It is already apparent that programmed instruction, although still in the stages of infancy, has made a breakthrough in education with practical dimensions that must be assessed. In the immediate future we will see a flurry of activity surrounding automation and its implications for special education. Programmed instruction will continue to grow and to improve as more faculty and students come to realize its potential value. The increasing number of programs available each year is an indication of the ever increasing interest in this medium. Much more testing and revising need to be completed, and many more statistics accumulated, before one can say with certainty programming is a permanent part of education. Programmed instruction will take its rightful and proper place as the newest medium of instruction, this place being to supplement, not to supplant.63


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