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RESEARCH MEMORANDUM

AN ANNOTATED BIBLIOGRAPHY ON THE
AUTOMATION OF INSTRUCTION

by

Charles S. Darby

Approved:

Robert U. Smith, Jr.
Robert U. Smith, Jr.
Director of Research

U. S. Army Air Defense
Human Research Unit
Fort Bliss, Texas
July 1959

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INTRODUCTION

The objective of U. S. Army Air Defense Human Research Unit Task TEXTWUCT is to produce and validate new or improved methods of instruction applicable to Army technical training courses. The initial phase of this program consisted of a search of the literature relevant to instructional and training techniques, methods and theory. The purpose of this search was to acquaint the research team with the current status of research and development in these areas and to furnish a firm basis for planning a research program.

Among recent approaches to the problem of increasing instructional efficiency, those of automating the instructional process and the use of "teaching machines" appear most fruitful.

The concept of a "teaching machine" first appeared¹ in the literature in B. L. Pressey's 1930 description of a device which "gives tests and scores and teaches" (5).² Essentially, the instrument allowed self-paced presentation of multiple-choice items to which the student responded by pressing one of several keys. On each item, the machine remained locked until the correct choice was made permitting the student to advance

¹B. F. Skinner at a recent conference described a "teaching machine" designed and patented by Halcyon Skinner in 1888. (Patent No. 78788.)

²Numbers in parentheses refer to references in the attached bibliography.

to the next question. By eliciting active student participation and by affording immediate knowledge of results, the machine could, and according to Pressay, did teach.

A variety of instruments providing for self-pacing and immediate reinforcement have subsequently been constructed. Ranging in complexity from the paper-and-pencil tab test through punchboards and chemical indicators to the Air Force Subject Matter Trainer, these devices differ only in form from Pressay's original machine.

The next significant advance in the development of automated instructional devices must be attributed largely to the efforts of B. F. Skinner. In 1964 Skinner (31) described a teaching machine which, in common with Pressay's, permits self-paced, immediately reinforced practice. The important difference lay in the nature of the material inserted in the machine. It is the purpose of this instructional material, or sequential program, to present the student with a situation in which the to-be-learned behavior (or knowledge) is acquired through successive approximation of the goal by steps of such small size that correct responding is virtually assured. The use of small steps and various techniques of prompting and leading allegedly insured the understanding of all the material covered in a program and, by generating a high percentage of correct responses, minimizes the extensive consequences of failure.

In addition to Skinner's machine procedure for automating instruction, another promising approach is that introduced by Crowder (39, 40, 41). This method, called "intrinsic programming," or alternatives

programming, differs from Skinner's in the role errors are allowed to play in progression through a program. As a result of variations in student input, Crowder believes it impossible to design a program in which a student can always be led to give the correct response. Thus, where Skinner strives to eliminate errors, Crowder provides for the commission of errors through multiple-choice questions and designs the program to give the student the information needed to correct the misunderstanding reflected in his choice of an incorrect answer.

While the mechanics of affording knowledge of results, the form of the student's response, and the nature of the instructional materials differ, the various "teaching machines" have several features in common. They constitute individualized learning situations in which the presence of a human teacher is not required. Active student response is elicited and some means of informing the student of the correctness of his response with minimal delay is incorporated. The learner's behavior affects the presentation of instructional material, e.g., rate, frequency, or increment of difficulty.

Proposals for automating the instructional process may be broader in scope than those advanced by the designers of teaching machines. Lucidaine, for example, states that "automated instructional methods can be considered generally to comprehend any means, devices or materials, whereby teacher or tutor functions (actual or desirable) are replaced, or provided, by a wholly or partially automated sequence of instructional

segments that is prepared in advance and is capable of instructing effectively when presented without direct intervention or modification by a teacher. They say thus include not only individual teaching machines as such, but several forms of recorded instruction via films, tapes, etc." (68). Although individual teaching machines are clearly more adaptable to differing rates of individual student progress, certain group-instruction techniques can offer some of the same advantages as individual teaching machines. Learning both from films and conventional classroom instruction has been facilitated through the application of one or more of the teaching machine techniques, e.g., controlled sequencing, prior programming, provision for active response, correction-feedback, etc. (45, 46, 53).

The obvious relevance of the developments in automated instruction to the objective of Task TEXTMOT has led to the assembly and digest of the attached bibliography. Articles and reports were drawn from the psychological, military, and educational literature. Some unpublished reports are included. The addresses of authors of unpublished papers are provided in the appendix.

Abstracts have been prepared to present only the general conclusions of experimental research or a general brief of the content of non-experimental articles. Where appropriate summaries were furnished with articles, these have been reproduced verbatim and are so indicated by quotation marks. Some abstracts were drawn from Hoos's (70) bibliography and are designated as such by his name in parentheses.

In 1967, Porter (73) published a review of a portion of the literature on teaching devices in which he classified and evaluated reports on various kinds of teaching aids and devices. An extensive bibliography was included. Titles of certain articles covered by Porter in his review are included, but are not abstracted. These items are indicated by Porter's name in parentheses following the citation.

The Air Defense Human Research Unit will welcome any suggestions as to ways of making this bibliography more complete or useful. It is intended to cover reports and articles published before March, 1969.

ORGANIZATION OF THE BIBLIOGRAPHY

In order to facilitate reference to the bibliography, items have been arranged in sections. These sections include articles dealing with specific kinds of devices (individual and group), abstracts of conference papers, and relevant articles of a theoretical or experimental nature.

SECTION I. INDIVIDUAL TEACHING DEVICES.

Articles in this section deal with the "automation" of individual learning situations. Included are references to self-scoring tests, the Subject Matter Trainer, Skinner machines and programming, and Crowder's "intrinsic" programming.

SECTION II. GROUP INSTRUCTIONAL DEVICES.

Selected references to the automation of group instructional situations are included. Articles in this section are representative of efforts to incorporate in the group situation one or more "principles of learning" which have been found to be generally valid, e.g., provision for active student practice and participation, correction-feedback, etc.

SECTION III. "PRINCIPLES OF LEARNING" -- SOME DISCUSSION AND RELEVANT EXPERIMENTATION.

There is a variety of theoretical and practical problems associated with the optimal means of exploiting, through automation and programming,

what we know about the learning process. Some problems relate to the role of errors in programming (Skinner vs. Crowder), the efficiency of errorless learning, the use of guidance in learning, and the relevance of the response to learning. Others relate to the most efficient means of affording knowledge of results and the effect of automation on learning.

This section includes references to literature in which principles of learning are discussed and to articles pertinent to some of the problems of programming and automation. Since the problem of the optimal application of "principles of learning" encompasses the whole of the field of learning theory, an extensive coverage of this literature was not attempted.

SECTION IV. LEARNING THEORIES: SOME GENERAL REFERENCES AND APPLICATIONS.

This section is designed to list for the interested non-psychologist some of the literature which deals with learning theories and attempts at their application, particularly with respect to human learning and training. No attempt has been made to be either representative or exhaustive in coverage. Items are not annotated.

ANNOTATED BIBLIOGRAPHY ON THE
AUTOMATION OF INSTRUCTION

1. Individual Teaching Devices

1. Self-Scoring Tests

1. Angell, G. H. and Troyer, K. L. A new self-scoring test device for improving instruction. 2nd. and 3rd., 1948, 67, 84-85. (Porter)

2. Bryan, G. L. and Rigney, J. W. An evaluation of a method for shipboard training in operations knowledge. Los Angeles: University of Southern California Report No. 18, Contract Nonr-226(O2), NR 153-091, September, 1956.

The effects on re-test performance of two kinds of knowledge of results furnished during a Tab Test administered to Naval ROTC students were compared. The students in one of two matched groups were told only whether they were right or wrong when they lifted the tab. The students in the other group were given a short verbal explanation of why any alternative selected was correct or incorrect. When compared on a multiple-choice criterion test, one week after the training session, the explanation of choice of group was significantly superior to the non-explanation group.

3. Bryan, G. L., Rigney, J. W., and Van Horn, C. An evaluation of three types of information for supplying knowledge of results in a training technique. Los Angeles: University of Southern California Report No. 19, Contract Nonr-226(O2), NR 153-073, April, 1957.

"The effectiveness of three types of explanations in a training device was evaluated by using each with a set of questions pertaining to Naval Operations. The types of explanations were: (1) definition or description of terms, (2) the most important reason why an alternative was correct or incorrect, and (3) probable operational consequences of selecting a course of action represented by an alternative. An explanation, concealed under a paper pull-off tab, accompanied each alternative response in a multiple-choice test. When the trainee moved the

ask and read the explanation, he learned whether or not his choice was correct and why."

Analysis of the data revealed that significant learning occurred as a result of the one hour training sessions with all of the three types of explanation employed. No one type of explanation was found to be superior.

4. Cantor, J. H. and Brown, J. S. An evaluation of the Trainer-Tester and Punchboard Tutor as electronics training aids. Naval Training Device Center, Special Devices Center, Office of Naval Research, Fort Washington, Long Island, New York, October, 1953, Technical Report NAYTRADVCEN 157-2-1.

An evaluation of two paper-and-pencil training aids. 1) The Trainer-Tester presents the student with a written list of symptoms exhibited by a malfunctioning piece of equipment and requires him to try a number of hypothetical tests and measurements to determine the defective component or the required adjustment. 2) The Punchboard Tutor allows the student to track down malfunctions by means of multiple-choice answers. In the Basic Electronics Course, students using the two training aids were superior to students using equipment only. In Advanced Radar Training, students who used the Trainer-Tester during basic training were superior to other groups in Radar Laboratory grades. (Root)

5. Jansen, S. T. An independent study laboratory using self-scoring tests. J. Educ. Res., 1946, 40, 184-187.

In this study of self-scoring tests, the author found that when the student was able to "find" the right answer at the time of taking the test, learning was facilitated. (Root)

6. Little, J. K. Results of use of machines for testing and for drill, upon learning in educational psychology. J. Exp. Educ., 1934, 3, 42-46. (Porter)

7. Peterson, H. J. and Peterson, J. O. A new device for teaching, testing and research on learning. Trans. Kans. Acad. Sci., 1930, 33, 44-47. (Porter)

8. Fresser, S. L. A simple device which gives tests and scores—and teaches. Ed. and Psy., 1924, 13, 373-374. (Porter)
9. Fresser, S. L. A machine for automatic teaching of drill material. Ed. and Psy., 1927, 25, 549-552. (Porter)
10. Fresser, S. L. A third and fourth contribution toward the coming "industrial revolution" in education. Ed. and Psy., 1932, 30, 666-672. (Porter)
11. Fresser, S. L. Development and appraisal of devices providing immediate automatic scoring of objective tests and concomitant self instruction. J. Psychol., 1950, 29, 417-447

Discusses the development of devices providing immediate automatic scoring of objective tests. The appraisal indicates that test devices allowing the subject to "find" the right answer at the time of taking the test contribute to increased learning. (Root)

12. Stone, G. R. The training function of examinations: Retest performance as a function of the amount and kind of critique information. Air Force Personnel & Training Research Center, Lackland Air Force Base, San Antonio, Texas. Research Report AFPRC-TN-55-8, June, 1955.

"The purpose of the present investigation was to study the influence of the amount and kind of information received by examinees in individual critique sessions on immediate and delayed retests on the same examination.

"The results indicated that critiques can produce significant benefits in student responses as much as 30 days following an examination and that the most effective kind of critique is one in which the student is told both what was correct and what was incorrect and why. (The use of negative information alone is not warranted.)"

B. Subject-Matter Trainer

13. Beard, C. G., Briggs, L. J., and Walker, E. S. The Improved Subject-Matter Trainer. Lowry Air Force Base, Colorado: Avionics Systems Personnel Research Laboratory, Air Force Personnel and Training Research Center, April, 1954. (Technical Memorandum AIRL TM-55-11).

"This report describes the improved prototype model of the Subject-Matter Trainer, a device designed to permit students to practice and learn technical subject matter under conditions of reinforced practice, with minimum aid of the instructor. A description of the earlier shop model of the device has been published previously.

"The Subject-Matter Trainer provides practice under a total of six modes of operation, five practice (learning) modes and one test mode. Each of the practice modes, while providing knowledge of the correctness or incorrectness of each response the student makes, gives varying amounts of assistance to the student, depending upon his own speed of learning and previous knowledge of the subject matter.

"The test mode of operation, usable in both classroom and laboratory, provides for testing students following learning sessions with the device. Two types of automatic scoring during practice are also provided."

The three general types of learning that can be used on the trainer are paired-associate, serial learning, and problem solving.

14. Briggs, L. J., Flahinski, D., and Jones, D. L. Self-pacing versus automatic pacing of practices on the Subject-Matter Trainer. Unpublished draft.

"The purpose of the present study was to determine whether, for a specified problem and a specified mode of operation, subjects would learn more in a given total practice period by pacing their own practice or by receiving the material automatically paced at an arbitrarily selected interval.

"Two groups of subjects were given approximately 13 minutes of practice on a twenty-item paired-associate problem. One group was allowed to pace the presentation of the stimuli; pacing was automatic for the other group. Both groups were then given a test trial.

"No difference between effectiveness of the two methods of pacing was demonstrated."

15. Briggs, L. J. Two self-instructional devices, Psychol. Bull., 1958, 54, 671-676.

"Two multiple-choice self-instructional devices are described. These enable S to learn correct responses to stimulus items without the aid of an instructor. S may work at his own speed, with knowledge of results after making each response. One device, on each practice trial, presents only items previously responded to incorrectly. Multiple modes of operation permit S to be shown the correct answers at the outset of practice, but require overt responses of him later. The modes may be selected to suit the difficulty of the material and the stage of learning simply by turning a knob. Control over the probability of error may be achieved by selection of the mode of operation to be used and by presentation of only a few alternative answers for each item."

16. Irion, A. L. An investigation of four modes of operation and three types of learning tasks on the Improved Subject-Matter Trainer. Unpublished draft.

"The comparative effectiveness of four modes (quiz, modified quiz, practice, and single-try) of practicing on the Improved Subject-Matter Trainer was investigated with three types of learning tasks (paired-associate, serial, and problem solving). The comparative effectiveness of the modes appears to be related to the type of learning task. The relationship between type of learning task and mode may possibly be confounded with the difficulty in learning the task. There was no statistically reliable indication that transfer of content from the paired-associate task to the problem solving task had taken place."

17. Mayer, Sylvia R. and Westfield, R. L. A Field Report of a Learning Machine for Training in SACB Operations. Operational Applications Laboratory, Air Force Cambridge Research Center, Air Research and Development Command, Bedford, Mass. October, 1958 (CAL Technical Memorandum 58-16).

"The experimental 'Subject-Matter Trainer' was tried out in SACB on-the-job training at the New York Air Defense Sector. In addition to an evaluation of the

effects of the trainer, information was collected on required characteristics of teaching machines for SAOE on-the-job training and on problems in the design, development and use of the required training materials.

"The results suggested that the experimental trainer would be useful for on-the-job training of SAOE operators. Administrative considerations related to the introduction of teaching machines into the SAOE system are pointed out and methods of handling them are suggested. Some areas are defined where research is needed for further development of automated teaching techniques."

C. Skinner Teaching Machines

18. Adkins, Dorothy C. Measurement in relation to the educational process. Educ. psychol. Monographs, 1958, 10, 881-940.

The educational system must be drastically altered in order to afford optimal conditions for learning for all students. The curricula must be revised "in the direction of a large number of learning units scaled according to difficulty within subject-matter areas." Mastery tests for each of these units must then be constructed.

"Several workers are contributing to these advances, among them B. F. Skinner, whose teaching machines and programming techniques represent contributions to both item scaling and mastery tests. 'If his plans fully materialize, posterity may . . . pay homage to (Skinner) chiefly as the sponsor of the century's most massive measurement movement.'"

19. Assel, A. Some comments on the manipulation of error responses and reinforcement schedules in self-instructional training devices. Unpublished paper.

The essential characteristics of Skinner teaching machines are described and the rationale underlying their development explicated. This author discusses two issues which emerge from Skinner's proposals: (1) the efficiency of errorless learning, and (2) the role of schedules of reinforcement in training. He concludes that "The use of partial

reinforcement schedules is recommended in training where feedback stimulation (indications of the adequacy of the behavior), when negative, should maintain a continuation of the same kind of performance until the complete adequacy of the behavior is indicated. Partial reinforcement in training is not recommended where behavior versatility is desired, and where feedback stimulation indicating performance inadequacy should result in changed performance."

20. Edwards, W. Skinner's teaching machines. Unpublished draft. (Porter)

21. Forster, C. E., and Sapon, S. M. An application of recent developments in psychology to the teaching of German. Mary. educ. Rev. 1966, 34, 55-60.

Principles of learning, proposed by B. F. Skinner, are applied in the teaching of German composition. Instructional materials were prepared and made available to 20 volunteer students. The students exposed the teaching materials by manually sliding a mask down each sheet of material. Six students completed the course in an average of 67.8 hours and learned an amount comparable to that covered in a first-semester course. These results suggested modifications in the program which are discussed.

22. Gilbert, T. F. Some recent attempts at the partial automation of teaching. A Report to the University of Georgia, Unpublished paper. 1966.

The author describes the "initial steps that have been taken to translate contemporary principles of learning into semi-automated classroom application." Several teaching machines are described in detail. One, a very simple device constructed from manila folders, was used with a program in college psychology and the results of its use are reported. This paper was the basis for a subsequent report by the same author to Bell Laboratories.

23. Gilbert, T. F. An early approximation to principles of progressing continuous-discretes. Self-instructional materials. A Report to Bell Telephone Laboratories, Inc., Murray Hill, New Jersey. September, 1966.

The author catalogues experimentally derived "principles of learning" and discusses their application to teaching. Although difficult, or impossible, to apply in the typical classroom, these principles have recently been incorporated in a learning situation through the development of teaching machines and programmed teaching materials. Several machines are described. Tentative rules for the construction of teaching programs are advanced and illustrations of their use are given. Procedures for analyzing programs and ways of classifying items in a program are proposed.

24. Hively, P. Implications of B. F. Skinner's analysis of behavior for the classroom. Harv. educ. Rev., 1960, 30, 57-62.

The relevance of Skinner's analysis of behavior to the educational process is discussed. The application of techniques derived from this analysis in the control of animal behavior, particularly the frequency and schedule of reinforcement, are illustrated. The similarity of these laboratory operations to the activities of teaching lead the author to propose their incorporation in the classroom. In particular, the teaching machine serves as a vehicle for such a proposal. The potentialities and limitations of teaching machines are considered with particular emphasis on their role as research tools.

25. Holland, J. G. A teaching machine program in psychology and its classroom use. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1958.

The results of a teaching machine program for Harvard's Behavioral Science course are discussed. Student performance on machine-taught test items was superior to that on lecture taught items. Problems of programming are described.

26. Israel, M. L. Skinnerian psychology and educational redesign. Paper presented at the 1960 APA Symposium sponsored by the APA Committee on the Relations Between Psychology and Education.

While the aims and goals of education have increased and expanded, the techniques of control available to the education have become less and less effective. Consequently, the educational process accomplishes little of the task set for it. Suggestions for

remedying this situation include both improving the techniques and expanding the scope of control. Judicious use of positive reinforcers, both artificial and natural, and broader manipulation of reinforcers would significantly improve the quality of the educational product.

27. Meyer, S. H. A program in elementary arithmetic: present and future. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1958.

The results of the use of the IBM arithmetic machine at the elementary level are discussed.

28. Porter, D. Teaching machines. Hart. Grad. Sch. of Educ. Assoc. Bull., 1958, 3, 1-6.

Teaching machines and devices are defined and described, and their effectiveness assessed in terms of the extent to which they make use of known ways of facilitating learning, e.g., frequency and immediacy of reinforcement. The application of these machines in the classroom is proposed and the mechanics of doing so explained. Suggestions for research in machine instruction are given.

29. Porter, D. Some effects of year-long teaching machine instruction in an elementary school. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1958.

The results of a teaching machine program in second and sixth grades are reported. A description of the machine used is given and the content of the program specified. On both second and sixth grade levels, spelling achievement was superior for the machine-taught group when compared with a conventional class.

30. Rath, G. J., Anderson, Nancy E., and Brainerd, H. C. The IBM Research Center teaching machine project. Unpublished paper, 1958.

This is a preliminary report of research using the IBM 650 Computer to simulate a teaching machine, with binary arithmetic as the subject matter. A detailed description of the rationale and method of teaching binary arithmetic is given and illustrated. The simulation of a binary output teaching machine is described.

21. Skinner, B. F. Science of Learning and the Art of Teaching. Harv. edus. Rev., 1954, 21, 66-97. (Part 1)

22. Skinner, B. F. Report No. 1 on the development of methods of preparing materials for teaching machines. Subcontract No. HMD-1-001. Unpublished draft. January 1, 1957.

The problems of determining the content of courses to be taught and the transforming of these statements of "what to teach" into a form suitable for use in a machine program are discussed. "In constructing a program, the principle concern is the elicitation of the correct response with a minimal chance of error."

23. Skinner, B. F. Report No. 2 on the development of methods of preparing materials for teaching machines. Subcontract No. HMD-1-001. Unpublished draft. April 1, 1957.

This report contains a discussion of the generation and programming, or ordering, of statements to be included in teaching material. Principles of programming should be applicable to any subject matter, exact, communicable, and effective.

24. Skinner, B. F. Final Report to Human Resources Research Office. Subcontract No. HMD-1-001. Unpublished draft. October 1, 1957.

A detailed description of Skinner's teaching machine and its use is given. The importance of the program used in the machine is stressed and some of the problems of programming are discussed. Some techniques of bringing the desired behavior under the control of the designated stimuli are "leading," "vanishing," and "prompting." The author discusses some of the reactions to teaching machines and argues for the efficiency of machine teaching.

25. Skinner, B. F. Teaching machines. Science, 1958, 122, 669-677.

The concept of a teaching machine originated with E. L. Thorndike's "immediate reinforcing" device in the 1920's. Thorndike's machines, however, succumbed to cultural inertia and inadequate theoretical support. Within a different theoretical framework, Skinner has

constructed a teaching machine which he describes in this report. Since the programming of the material used in the machine is of paramount importance, a detailed analysis of this task is given along with an example from a physics program. Problems related to the acceptance and use of teaching machines are discussed.

26. Skinner, B. F. The use of teaching machines in college instruction. Final Report to the Fund for the Advancement of Education. August 18, 1958.

"This is the final report of work done under two annual grants by the Fund for the Advancement of Education in investigating the place of teaching machines in the utilization of college teaching resources. It consists of four parts:

"Part I is a general discussion of machine instruction. It is written as a separate paper and is published in Science, 1958.

"Part II is a detailed statement of the most useful features of teaching machines in the present state of the art.

"Part III is an analysis of the problems of programming knowledge for machine instruction.

"Part IV is a detailed report of our experience in teaching part of a course on Human Behavior at Harvard and Radcliffe in the Spring term, 1958."

27. Skinner, B. F. The programming of verbal knowledge. Paper presented at the ALP Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1958.

The problem of establishing the form of the verbal response to be emitted by the student in the instructional situation and the ways of bringing these responses under the control of verbal and non-verbal stimuli are discussed.

38. Skinner, B. F. Skinnerian theory of teaching machines.
Paper presented at the Air Force Office of Scientific
Research and the University of Pennsylvania Conference
on The Automatic Teaching of Verbal and Symbolic Skills
in December, 1955.

Skinner's theory says that the appropriate
experimental paradigm for constructing and
programming teaching machines is that of free
operant conditioning. It is argued that exist-
ing machines represent admixtures of at least
three paradigms, free operant, controlled
operant, and classical conditioning, and that,
of these, the free operant may be the least
pertinent. Thus Skinner's theory leads to the
neglect of a large body of relevant experi-
mental literature.

D. Crowder "Intrinsic" Programming

39. Crowder, W. A. Automatic tutoring by means of intrinsic
programming. Unpublished paper.

The "scrambled book" technique of automatic tutoring
is described. As a result of variations in student
input in the learning situation, this author be-
lieves it impossible to design a program in which
the student can always be led to give the correct
response. Thus, the presentation of information
is followed by a multiple-choice question which
provides for the commission of an error. The
student's choice directs him to another page in
the book which either confirms his response or
furnishes the information needed to correct the
misunderstanding reflected in his choice of an
incorrect answer. Since pages are not followed
sequentially, the book is called "scrambled."
This procedure is called intrinsic programming.

40. Crowder, W. A. The concept of automatic tutoring.
Air Force Personnel and Training Research Center, Air
Research and Development Command, Lackland Air Force
Base, Tex., Organizational paper.

Automatic tutoring attempts to simulate the entire
learning situation without either an instructor or
the apparatus which is the subject of instruction.

The student is presented with a book in which he finds a question followed by a list of alternative answers. Choosing the answer he thinks correct, he turns to the page the answer indicates and finds whether he is right. If not, he is informed what was wrong with his answer and instructed to return to the original page and try again. When he is correct, the text gives him more information and leads him to the next question. The main disadvantage of this method of instruction is that the student is cued by the list of possible alternatives, the author says. He feels that this method has definite possibilities for augmenting direct instruction in a formal or an on-the-job training course at comparatively little cost in time or material. (Root)

41. Crowder, N. A. Automatic tutoring by means of intrinsic programming. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1960.

It is assumed that students will make errors in learning and that the form of the response a student makes to a teaching device is irrelevant to learning. Hence, the "scrambled book" in which items of information are followed by multiple-choice questions. The student's response is to select a page corresponding to his answer. On turning to the page, his response is either confirmed or corrected.

42. Day, J. H. Teaching Machines. Unpublished paper.

II. Group Instructional Devices

A. Films

43. Ash, P. and Jaepen, H. The effects and interaction of rate of development, repetition, participation, and room illumination on learning from a rear-projected film. Special Devices Center, Office of Naval Research, Fort Washington, Long Island, New York, October 1960, Human Engineering Report NRO 60-7-80.

intended to determine whether it is possible, when teaching a skill with films, to have trainees participate along with the demonstration. With enough light and slow enough film demonstration, trainees could practice and participate. A slow rate of development, repetition, and participation all increased learning. Interaction between repetition and rate of development was found; this suggested that repetition cannot entirely compensate for a fast rate of development in a film. (Root)

44. Hirsch, R. S. The effects of knowledge of test results on learning of meaningful material. Special Devices Center, Office of Naval Research, Fort Washington, Long Island, New York, September, 1958, Human Engineering Report SDC 869-7-50.

Investigated the effect of knowledge of results in a realistic training situation with highly meaningful material. In this experimental training situation the instructional material consisted of six Navy training films covering aerodynamics, the carbine rifle, theory of guided missile operation, hydrostatic fuses, navigation plotting board, and star identification. It was found that in general the more explanation given with the correct answer, the more the answer aided learning. (Root)

45. Hayland, C. I., Lumsdaine, A. A., and Sheffield, F. D. Experiments on mass education. Princeton: Princeton University Press, 1949.

Includes reports of film studies by the Experimental Section, Research Branch, Information and Education Division of the War Department. The problems investigated include opinion and motivational effects of orientational films; factors in audience response, and effects of alternate methods of presentation of audience participation. (Root)

46. Kurts, A. K., Walter, J. S., and Brewer, H. R. The effects of inserted questions and statements on film learning (rapid mass learning). Special Devices Center, Office of Naval Research, Fort

Washington, Long Island, New York, September, 1960,
Technical Report NDC 288-7-16.

The investigators found that the insertion of questions in the sound track of a film improved learning but was no more effective than a repetition of the film. (Doct)

47. Margolius, G. and Maceoby, N. Methods of combining practice with filmed demonstration in teaching simple response sequences. Paper read at the American Psychological Association, 1956.

Optimum methods for combining filmed demonstration and practice in learning a lengthy, complex, serial, manual task were investigated. In all four experimental groups the learners saw the entire mechanical assembly three times; what was varied was the timing of demonstration and practice used prior to the final test. The results indicated that when training was in accordance with theoretically prescribed demonstration and practice segments, or when demonstration and practice were lengthened during succeeding trials, performance of the task was optimum. When training segment length exceeded the theoretically prescribed length, test performance was lowered. (Doct)

48. Michael, D. N. and Maceoby, N. Some factors influencing the effects of audience participation on learning from a technical film. Human Resources Research Laboratory, Headquarters Command, USAF, Bolling Air Force Base, Washington, December, 1961. NARL Memorandum Report 15A.

Assessed the relative contributions of practice and motivation factors to the increased teaching efficiency of film showings which use a participation procedure. In addition, three experimental conditions were studied which were expected to affect the level of learning. Within the conditions of the experiment, audience participation procedures utilizing either covert or overt practice with the presence of correct responses (feedback) were

found to result in considerable improvements in learning verbal material. "This increase in learning seems to be due primarily to the effects of practice and not to the effects of changes in motivation to learn. The most important factor influencing the learning was the provision of knowledge of the correct response after practice (feedback)." (Reet)

89. Michael, D. N. and Macosky, N. Factors influencing verbal learning from films under varying conditions of audience participation. J. educ. Psychol., 1951, 43, 411-418.

A film was interrupted four times to permit practice in answering questions based on the preceding section of film. On the test which followed there were no differences between subjects who had written out answers during practice and subjects who had been instructed to "think" the correct answer. The participation subjects were superior to groups without any kind of practice. Knowledge of results was the most important variable that differentiated between the different conditions of presentation, subjects informed of the answers to practice questions being superior on the final test. (Reet)

90. Yale Motion Picture Research Project. Do motivation and participation questions increase learning? Educ. Research, 1947, 16, 266-269, 274-282.

This study of the effect of questions inserted in an instructional film showed that the questions helped facilitate learning, and that writing answers to the questions presented was also effective in helping the student learn from a biological film. (Reet)

B. Classroom Communicator

91. Carpenter, G. N., et al. The Classroom Communicator. Special Devices Center, Office of Naval Research, Fort Washington, Long Island, New York, October, 1950, Technical Report SDC R50-7-14.

A report of the planning, design, and construction of experimental equipment appropriate for research on the learning process and evaluation of complex instructional and informational programs. The Classroom Communicator provides a means for recording and measuring the individual reactions in the audience and improving, facilitating, or increasing the rate and effectiveness of learning. The device consists of individual response stations connected to a central unit, which allows the observer or instructor to see the percentage of correct answers as well as the percentage for each of the remaining four possible alternatives.
(Rout)

88. Henry, E. W. and Webb, W. B. Facilitation of learning by the Classroom Communicator, in Henry, E. W., Webb, W. B. and Garvin, E. A. Studies in Air Technical Training, St. Louis, Missouri: Washington University, Department of Psychology and Office of Naval Research, December, 1955, Technical Report No. 2, Nour 616(OR)

"This study attempts to evaluate the effectiveness of a modified Classroom Communicator as a teaching device. This instrument consists of switch boxes attached to student desks and connected to a panel on the instructor's lectern. Students responded to questions flashed on a screen intermittently throughout the lecture. By looking at the panel, the instructor could determine the level of understanding of each member of the class. He could then give the correct answer and clear up any points of confusion.

"The results of this study indicate to a high degree of probability that the modification of the Classroom Communicator of this experiment can be used effectively to facilitate the learning of material verbally presented in a classroom situation."

III. Theoretical Issues and Some Relevant Experiments

89. Ammons, R. S. Knowledge of Performance: Survey of literature, some possible applications, and

suggested experimentation. Wright Air Development Center, Air Research and Development Command, Wright-Patterson Air Force Base, Ohio, 1944, WADC Technical Report 54-14.

"This report represents a systematization of much of the currently available information concerning the influence of knowledge of performance on learning, performance and transfer of training. The results of a large number of studies are organized into eleven empirical generalizations. Some possible applications of the generalizations to the design of training equipment are discussed and needed research studies, ranging from specific experiments to needed area programs, are indicated."

54. Cook, J. On some methods of programming. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1958.

Teaching rules, or ways of restricting students' responses so as to facilitate the emission of the wanted response, are discussed. Examples of restricting techniques are prompts, copying, and analogy.

55. Bennett, G. K. Development of a Morse code actuated printer. RAND Report 5455 VRI 10038. Washington Psychological Corporation, 1945.

A brief description of the device is provided on page 1270 of the Handbook of Experimental Psychology. (54).

56. Briggs, L. J. Teaching machines for use in training military personnel in maintenance of electronic equipment. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1958.

Four "teaching machines" are discussed: the Subject-Matter Trainer, a Card-Sort Device, a

Complex procedural Trainer, and a Troubleshot-
ing Trainer.

47. Briggs, L. J. Teaching machines, education, and job
skills. Psychol. Rep., 1966, 9, 210.

48. Bushwaid, A. M. Extinction after acquisition under
different verbal reinforcement combinations. J.
exp. Psychol., 1959, 57, 43-44.

"College students were given 144 trials of
learning on a task requiring S to spell one of
a pair of nonsense syllables presented to him.
The S said 'Right' following an A-response and
nothing following a B-response; nothing follow-
ing an A-response and 'Wrong' following a
B-response; 'Right' following an A-response and
'Wrong' following a B-response for S₁ in the
RM, RW, and RW groups, respectively. On 72
additional trials S said nothing regardless of
S's response.

"Acquisition of the A-response occurred most
rapidly in the RW group followed by RW and RM
in the order. When S followed all responses
the amount of extinction of the A-response was
found to be greatest for the RM group. For the
majority of RW and RW Ss, B-responses do not
occur on extinction trials. Further data
analyses indicate that extinction differences
are not attributable to differences in extent
of acquisition. The results were interpreted
as confirming the assumption that S becomes a
negative reinforcer during acquisition under
the RM condition."

49. Cook, J. O. Processes underlying the learning of a
single paired-associate item. Unpublished paper.

"This experiment compared two training pro-
cedures in paired-associate learning: Prompt-
ing (presenting the response term between the
presentation of the stimulus term and the
written practice of the response) and Confirma-
tion (presenting the response term after the
written practice of the response). A theory
asserting that paired-associate learning

involves particular mediating S-R connections predicted that throughout the middle segment of the learning curve the Prompting procedure would yield significantly more correct responses than the Confirmation procedure. The results are in accordance with the theory."

60. Gilbert, A. C. F. Effect of immediacy of knowledge of correctness of response upon learning. *J. educ. Psychol.*, 1960, 47, 616-422.

Two matched groups of students took the same examination. One group used the SRA Self-Recorder in taking the test. The other group followed the examination with a class discussion of the test items. Using student gains on a retest as the criterion, the group given an explanation of the test was significantly superior to the group using the SRA Self-Recorder.

61. Gilbert, T. F. An early appreciation of principles of analyzing and revising self-instructional programs. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1958.

Rather than compare self-instructional programs with classroom instruction, programs should be analyzed in terms of the extent to which they incorporate those factors essential to teaching. Programs should be constructed, used, and the results analyzed. Analysis should reveal rules of programming.

62. Glaser, M. Knowledge of learning and methods of training. Unpublished paper presented to the Psychology Department Colloquium, Univ. of Pittsburgh, February 26, 1958.

Prepared for a group of psychologists, this paper is a somewhat more technical version of a chapter appearing in Glaser and Glaser, Training and Training Research. It attempts to assess the role that the science of learning can play in the applied psychology of learning. Several variables related to learning are

listed and discussed. These include: practice, task guidance, reinforcement, extinction, meaningfulness, punishment, transfer of training, etc.

63. Glasser, A., and Glasser, M. Training and training research. Pittsburgh, Univ. of Pittsburgh and Amer. Institute for Research, Contract Monr-3881(00), August, 1958.

This report discusses the problems faced by a training research specialist in establishing and evaluating specific training programs or in undertaking training research. Four steps followed in the course of developing human resources are described: (1) the specification of training objectives, (2) input control, or the specification of prior education, etc., at the beginning of the training process, (3) training procedures or the actual procedures for modifying the behavior, and (4) output control or the development of criterion instruments and measures.

64. Glasser, M., Homme, L. B., and Evans, J. An evaluation of textbooks in terms of learning principles. Paper presented at the meetings of the American Educational Research Association, February, 1959.

65. Greenappon, J. and Foreman, S. Effect of delay of knowledge of results on learning a motor task. J. exp. Psychol., 1956, 51, 280-286.

"The effect of delaying reward on the learning of a motor task by human Ss was investigated. The task required Ss to draw a 2-in. line while blindfolded. The information concerning the accuracy of the line was delayed for 0, 10, 30, and 50 sec. in four different experimental groups. No information was given to Ss in the control group. The results indicate that increasing the length of the delay interval reduced the rate of learning. A delay up to 30 sec. was found to be superior to no information."

66. Neenan, L. A., and Gleaser, A. Relationships between the programmed textbook and teaching machines. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1958.

A "programmed textbook" is described. Program frames are printed on one side of a page, the answers on the reverse side. Thus the student merely turns the page to confirm his answer. When compared with conventional texts the effectiveness of the programmed text was uniformly supported. Increasing the number of steps and decreasing step size led to better mastery of the material. More errors on the program are associated with more errors on the achievement test.

67. Resdler, R. Teaching machines and psychological theory. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1958.

It would be both useful and advantageous to distinguish between the teaching machine as an educational machine and as an expression of Skinner's theoretical position in the psychology of learning. The purpose of this paper is to raise problems associated with the teaching machine that seem to demand the collaboration of theoretically oriented psychologists.

68. Lumadaine, A. A. Partial and more complete automation of teaching processes: Some psychological and economic factors. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1958.

"Automated instructional methods can be considered generally to comprehend any means, devices, or materials, whereby teacher or tutor functions (actual or desirable) are replaced, or provided, by wholly or partially automated

sequence of instructional segments that is prepared in advance and is capable of instructing effectively when presented without direct intervention or modification by a teacher."

Concerning the flexibility of the individual teaching machine, this speaker urged that the possibilities of automated group instructional devices not be overlooked. Some group devices are described. Further research is needed on machine design and construction and on the programming of material for use in the machine.

66. Maccoby, H., and Sheffield, F. D. Theory and experimental research on the teaching of complex sequential procedures by alternate demonstration and practice. Paper presented at the 1956 AF-ED Science Symposium on Personnel, Training, and Human Engineering. (Distributed as Technical Memorandum AF-TD-57-51, December, 1957.

This study was concerned with optimum methods for combining demonstration and practice. The minimum size of demonstration and practice step used was the "demonstration-assimilation span" or "D-A span" which is defined as a segment of demonstration that approximately 75% of subjects could perform immediately without error. Four conditions of training were used: smallest segment, larger segment, whole task, and transition from small segment to whole task. Tasks employed were mechanical assembly and geometric construction. The transition condition was the most effective.

70. Mollen, Inert. Teaching and educational inventions. J. exp. Educ., 1936, 4, 181-200.

A brief article giving descriptions of several teaching devices, patent titles of several dozen, and patent numbers referring to many devices from the early 1800's to the article date. (Abstracted by D. Porter)

71. Porter, D. A report on the use of audio-visual aids in foreign language teaching. Prepared for The Fund for the Advancement of Education, April 16, 1950.

A review of current practices in the use of teaching aids with recommendations for more effective use of current equipment. (Abstracted by D. Porter)

72. Porter, D. A report on instructional devices in foreign language teaching. Prepared for the International Training and Research Program of the Ford Foundation, October 1, 1958.

Specific recommendations for the implementing of a language package for self-instruction in Russian. Considers research versus teaching uses of teaching machines along with some preliminary notions about programming language materials. (Abstracted by D. Porter)

73. Porter, D. A critical review of a portion of the literature on teaching devices, Harv. educ. Rev., 1957, 27, 122-127.

A classification of mechanical teaching aids and devices is developed. Teaching aids may be either stimulus devices, e.g., films, or response devices, e.g., typewriters. The term "teaching device" is reserved for "the stimulus-response type of device which is capable of teaching without the mediation of a human teacher." This review is restricted to the literature on immediately reinforcing, stimulus-response devices. Descriptive, theoretical, experimental, and evaluative articles concerning these devices are summarized and appraised. An extensive bibliography is included.

74. Kano, E. A new technique of education, Institute of Radio Engineers Trans. on Education, 1958, 2-1, 27-31.

The author argues that we currently possess a technology with which to improve the educational process. The educational process is considered a "man-machine" system in which human capabilities may be extended by new engineering systems.

Examples of areas in which education may be automated are administrative functions,

(scheduling of classes, roll taking, etc.) and the feedback process in lecturing.

75. Roth, G. J. and Anderson, R. J. The IBM Research Center teaching machine project. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1956.

The IBM 650 computer was programmed to simulate a teaching machine with binary arithmetic as the subject matter. The characteristics of a teaching machine are described.

76. Roth, R. F. An annotated bibliography of research on training aids and training devices. Training Methods Division, Human Resources, The George Washington University, Washington, D. C., August, 1957. Staff Memorandum.

77. Rothkopf, Ernst. Heuristic discussions of psychological bases for the design of training by automatic devices. I. A functional diagram and an approach to research. Unpublished paper.

Describes possible divisions of function between various components of an automatic teaching device. It is suggested that the ultimate design of a teaching device be shaped up through a series of successive approximations by simulating device functions in a mock-up design. (Abstracted by D. Porter)

78. Smith, D. E. P. Speculations: Characteristics of successful programmers and programmers. Paper presented at the Air Force Office of Scientific Research and the University of Pennsylvania Conference on The Automatic Teaching of Verbal and Symbolic Skills in December, 1956.

Principles and techniques of programming are proposed. Successful programmers are most likely to have an inverted style of thinking. It is suggested that an introversion-extraversion measure may facilitate the selection of programmers.

79. Skinner, B. F. Proposed "automatic" teaching device, Institute of Radio Engineers Trans. on Elec., 1948, Vol. 61-41.

An "automatic" teaching device is defined as one which incorporates both the presentation of information and the testing of the student in a controlled feedback relationship. This paper argues for the use of such machines and presents some proposals for their construction.

80. Skinner, B. F. Electronic teaching devices, NSA Laboratories, Princeton, N. J., NSA TR No., 51.

IV. Learning Theories: Some General References and Applications.

81. Deane, J. The Psychology of Learning, New York: McGraw-Hill, 1938.
82. Department of Defense. Symposium on Psychology of Learning Basis to Military Training Systems (AR-67D 701/1) Panel on Training and Training Devices, Committee on Human Resources, Research and Development Board, 7-8 May, 1955.
83. Bates, W. W., et al. Modern Learning Theory, New York: Appleton-Century-Crofts, 1954.
84. Forster, C. R., and Skinner, B. F. Schedules of Reinforcement, New York: Appleton-Century-Crofts, 1957.
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89. Skinner, B. F. Science and human behavior. New York: MacMillan, 1953.
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95. Woodworth, R. S., and Schlosberg, H. Experimental psychology. New York: Holt, 1954.

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Wright, D., 82

APPENDIX

ADDRESSES OF AUTHORS OF INVITED PAPERS

1. Ansel, Abram
Department of Psychology
Newcomb College
Tulane University
New Orleans 18, Louisiana
2. Anderson, Nancy B.
IBM Research Center
P. O. Box 218
Yorktown Heights, New York
3. Briggs, Leslie J.
Hughes Aircraft Co.
Maintenance Engineering Staff
Building 18
Mail Station 888
08-81-00
Palmdale, California
4. Cook, John O.
North Carolina State College
Raleigh, North Carolina
5. Crowder, Norman A.
Western Design and Manufacturing Corp.
Santa Barbara Airport
Goleta, California
6. Day, Jesse H.
Department of Chemistry
Ohio University
Athens, Ohio
7. Gilbart, Thomas F.
Psychological Laboratories
~~Harvard University~~
Cambridge, Massachusetts
8. Glaser, Robert
Department of Psychology
University of Pittsburgh
Pittsburgh 18, Pennsylvania
9. Irwin, A. L.
Department of Psychology
Tulane University
New Orleans, Louisiana
10. Israel, Matthew
Kamerial Hall
Harvard University
Cambridge 38, Massachusetts
11. Roth, Octave J.
IBM Corporation Research
Center
P. O. Box 218
Yorktown Heights, New York
12. Rothkopf, E. E.
Bell Telephone Laboratories
Murray Hill, New Jersey
13. Skinner, B. F.
Psychological Laboratories
Harvard University
Cambridge 38, Massachusetts

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