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Teaching machines: a means of re-evaluating and implementing training procedures.

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TEACHING MACHINES: A MEANS OF
RE-EVALUATING AND IMPLEMENTING
TRAINING PROCEDURES

by
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CHAPTER I
INTRODUCTION

A Survey of Circumstances Underlying the Arrival of Automated Teaching

"If one of the values of American education is to remain the achievement of individual excellence, some method has to be found to permit more attention to the individual student."

G. S. Counts
INTRODUCTION

"The invention of printing freed the scholar from almost complete dependence upon the teacher and permitted individuals who possessed sufficient initiative and intelligence in some instances to achieve a truly broad and deep background with a minimum of formal classroom instruction. We are now on the threshold of a further step toward the possibility of simultaneously permitting greater independence for the individual scholar and potentially, as with the invention of printing, a great enrichment of the possibilities of the contribution of the classroom teacher." (3, p.15)

Automation has finally invaded the field of education. Before we rejoice or lament this fact, we would do well to review the reasons for this entry and the potential contribution of self-instruction devices. Experimental evidence will help us further to evaluate the place of automated teaching in the schools, offices, and industries of tomorrow.

The objectives of this thesis may be stated in terms of a two-fold exploratory preparation: for the utilization of teaching machines in the instruction of the curriculum at the School of Public Relations and Communications, and for an examination of the possible industrial applications of such devices.* The selection and development of manpower is one of the primary problems of industry; with the increased demand for greater

* e.g., selection of personnel via machine testing; teaching facts and skills; studying message structure (in preparing advertising, training manuals, etc.); researching characteristics of 'publics'.
specialization and more training, it is our responsibility to examine new methods that could rise to meet the demand.

No defense is necessary for any program that will increase the efficiency of present-day teaching methods in the field of education itself. An increasing world population demands more and more education, a demand which cannot be met simply by building more schools and training more teachers. Education must become more efficient. To this end curricula must be revised and simplified, and textbooks and classroom techniques improved. As Skinner has pointed out:

"In any other field a demand for increased production would have led at once to the invention of labor-saving capital equipment. Education has reached this stage very late, possibly through a misconception of its task. Thanks to the advent of TV, however, the so-called audio-visual aids are being reexamined. Film projectors are finding their way into the American schools and colleges." (40)

Critics of the automated teaching approach usually picture a totally impersonal form of instruction where the teacher is replaced by the machine. This is clearly not the intent of the machine. According to Skinner:

"Audio-visual aids supplement and may even supplant lectures, demonstrations, and textbooks. In doing so they serve one function of the teacher: they present material to the student, and when successful, make it so clear and interesting that the student learns. But there is another function to which they contribute little or nothing. It is best seen in the
productive interchange between teacher and student in the small classroom or tutorial situation. Much of that interchange has already been sacrificed in American education in order that we may teach large numbers of students. There is a real danger that it will be wholly obscured if use of equipment designed simply to present material becomes widespread. The student is becoming more and more a mere passive receiver of instruction." (40)

The National Education Association is vitally interested in the question of automated teaching, and defensive when the in-person role of the teacher is threatened. In a booklet entitled Mass Communication and Education (1958), experiments are cited which compare in-person teaching techniques with straight media presentations. The in-person approach is indicated as superior. Such classic experiments as those of Wilke (44), Allport and Cantril (1), Lazarsfeld, Berelson, and Gaudet (27), Hovland, Lumsdaine, and Sheffield (21), and Klapper (25) all testify to the importance of the physical presence of the communicator. From such evidence the NEA concludes:

"Regardless of the particular technique used, one element must be constantly present: the teacher. The advantage of face-to-face communications, the ability to modify constantly the approach to fit changing circumstances, and to adapt it to the individual—these are characteristics too valuable to be sacrificed in any methodology." (30, p.92)

Objections to impersonal media and visual aids are
numerous. They are perhaps best phrased in the poetry of Kenneth E. Boulding, Professor of Economics at the University of Michigan:

"People above the Second Grade
Seldom require the Visual Aid;
The chart that eye cannot quite reach
Is not a substitute for speech,
And folks are seldom made to laugh
By diagram or flannelgraph,
And don't accept with gratitude
The List, served up with platitude.

But gladly under him they sit
Whose information's spiced with wit;
Whose face bespeaks a good digestion,
Whose mind is quick to catch a question,
Who keeps all crutches at a distance,
And speaks his piece without assistance,
Using the blessed power of speech
To learn, himself, as well as teach." (4)

But what is the common denominator underlying objections to visual aids and to other media that supplement and sometimes supplant the teacher? Isn't it the impersonality of such teaching methods that is under fire? Some researchers, in fact, feel that the superiority of in-person communication is so constant that the inferiority of other kinds of presentation can be measured in terms of how far they depart from face-to-face techniques. (30, pp. 82,83) These researchers, however, refuse to consider the possibility that there might exist great variance in ability to communicate effectively, assuming an exclusively personal situation. Secondly, sentimental considerations have replaced objective in-
spection of the teaching-learning process. Since most researchers are themselves teachers, they have been loath to examine the question of how 'personal' the classical student-teacher relationship is, and how 'impersonal' the teaching aids are. For example, is a good textbook less personal than a poor teacher? Advocates of automated teaching have held that self-instruction devices meet the individual needs of a student far better than most classroom situations. He can, for example, work at his own rate; brighter students are not penalized by the slower students in a class. His attention is held, since he cannot advance to new material until he has mastered preceding material. And in the classroom, students may be thinking of a score of extra-curricular matters while the teacher plods on, unaware of almost total inattention. Further, Pressey (33) pointed out that the usual examination or assignment correction may take from several days to several weeks. After such a delay, student behavior is not appreciably modified. And, according to Thorndike (42), if behavior is not modified, learning has not taken place. Thus, the immediate report supplied by a self-scoring device can have an important instructional effect.

Norbert Wiener (43) reminds us that man has served as the model for the most complex self-governing devices and computer systems known. It seems surprising that in
an age of servomechanisms - radar, sonar, the thermocouple, the gyrocompass, to name but a few - we have overlooked the process of feedback in the prototype servomechanism: man. Here, in the author's opinion, is the crux of the inefficiency of present educational methods. Until each student becomes at once his own teacher, lasting and meaningful learning (tailored to individual understanding and needs, and characterized by modified behavior) will not take place. The teaching machine, unique among visual aids and other instructional devices, offers the student the immediate feedback that enables him to become his own teacher.

To recapitulate, a self-instructional program of learning via the teaching machine, when effectively planned (programmed), can be far more personal and thus meaningful to the student than the often impersonal situation of a crowded classroom. Far from replacing the teacher, the automated instruction program replaces the burden of imparting routine expository material and thus relieves the teacher for higher levels of instruction; e.g., planning the use to be made of such knowledge, preparing students to teach themselves, working individually with students, etc. The real result of this changed role of the teacher may be to raise his activity to a new level of professional significance. (30, p. 100)
If the advantages herein outlined apply to educational instruction, they are doubly valid in the industrial framework. For here, presumably, employees are aware of their purposes and goals, and have an increased desire to improve themselves (raises, promotions, etc.). In the voluntary employee training program, motivation is assumed to be built-in. And in the area of indoctrination and orientation, new personnel are expected to want to know more about their company’s plans, programs, processes, and personnel.

Finally, in research in the mass media as they relate to advertising and public relations, it is quite possible that the teaching machine could become an effective tool in studying message structure and increasing control and predictability of reception. If, for example, the teaching machine could make management define the objectives of a particular publication*, determine what steps are necessary to reach them, and provide a continuous record of the extent to which the publication fulfills or falls short of these objectives (through the feedback required on answer tape), then such a device would find a welcome place in business and industry. We are here not concerned with programming as a means to low-error student feedback, but rather the machine’s use in presenting and receiving simul-

* e.g., employee handbooks, stockholder reports, policy statements, training manuals, etc.
taneous - and thus spontaneous - 'communicator feedback'. This latter type serves to correct the message source rather than its reception.

This study, then, consists of an examination of the expanded application of the principles of self-instruction, as well as the necessary exploratory preparation for the installation of automated teaching devices in business, industry, and education. To this end, we will examine the literature available to date, apply the principles of learning theory and educational psychology to automated teaching, visit the Harvard Self-Instruction Center, and examine experimental results of the automated teaching program used in a segment of the Corporate Journalism course (PR 331) at Boston University. Hopefully, the results arrived at will be of use to educators, communicators, and administrators alike. For only through such a critical evaluation of the teaching process itself and its implementation through more efficient methods of imparting knowledge will we be able to meet the demands of education and industry ... demands which are with us today.
CHAPTER II
HISTORICAL BACKGROUND

A Brief History of Self-instructional Devices
and Automated Teaching

"The fact that the mechanical rigidity of the insect is such as to limit its intelligence while the mechanical fluidity of the human being provides for his almost indefinite intellectual expansion is highly relevant ... theoretically, if we could build a machine whose mechanical structure duplicated human physiology, then we could have a machine whose intellectual capacities would duplicate those of human beings."

Norbert Wiener
HISTORICAL BACKGROUND

From time immemorial teachers have utilized various materials as teaching aids. These aids present the physical stimuli which serve as vehicles for the spoken or written message. Often such stimuli indicate to the student that a certain response is appropriate. How, for example, could we teach music harmony without a piano... or engineering drawing without a drafting set? Even in those disciplines where skills are measured in terms of understanding and the resulting patterns of reasoning, teaching aids are indispensable (e.g., lab demonstrations, graphs, tables, charts, etc. in the natural and social sciences).

Although the aids are physical stimuli that facilitate understanding, the student is expected to respond, usually by behavioral changes, if learning has taken place. (41, 42) It is here that teaching materials provide the setting in which and with which a student's responses may be perfected.

In 1957 Porter published his exhaustive review of the literature on teaching devices. For convenience, he classified all mechanical teaching aids in three categories: (36, pp.128,129)

1. Stimulus Devices - which present information about how or when to make a given response, but not provide a setting for the practice of responses.
Thus, stimulus devices provide learning content without any assurance that a learning process will be carried out (e.g., models, films, records, radio and TV, etc.).

2. **Response Devices** - which provide an opportunity to practice responses. They may also be used to gather, record, and transform coded data about the nature of the responses being made. But they provide no stimulus information about the circumstances under which particular behavior is appropriate. Thus, responses are related solely to the mechanical properties of the machine and not to the subject matter content. (e.g., typewriters, calculators, slide rules, recorders, automatic test scorers, etc.)

3. **Stimulus-Response Devices** - which present cues and opportunities for response. Such devices are designed to present a sequence of stimuli (content) and provide the setting in which appropriate responses may be made and rehearsed (process). (e.g., chemical paper, punchboard, electric answer board, metronoscope, ophthalmograph, and tachistoscope, and a variety of teaching machines)

Obviously, such a classification will have overlapping of categories. Thus the phonograph record, a stimulus device, becomes a stimulus-response device when provision is made for student response (as in language training records). Similarly, the punchboard or electric answer board could be memorized and mastered by a student without the appropriate stimulus material. Such devices would then become mere response devices on the basis of their use.

It is apparent that stimulus-response devices more nearly reproduce the characteristics of teaching which are required for efficient learning than do either
stimulus devices or response devices.* These latter two categories are thus not teaching devices but rather teaching aids. For our purposes, then, we are concerned only with the stimulus-response type of device which is capable of teaching without the mediation of a human teacher.

There is one further characteristic common to the teaching machines which we shall examine: reinforcement is immediate. This means that the student is presented with a reward, or reinforcement, immediately after responding correctly to each item. (The Foringer machine for mentally disturbed children awards marbles which drop into a cup (12); the Pressey multiple-choice machines employed an optional device which presented a small piece of candy after a predetermined number of correct responses (33); in most teaching machines, however, the knowledge that he has answered correctly is considered to be reinforcement enough for the mature student (40).)

The Multiple-Choice Machine: The earliest reference to a teaching machine which meets the criteria of a stimulus-response device with immediate reinforcement is the

* The word 'teacher' itself implies that knowledge has been imparted and learning has taken place. The 'professor' or 'lecturer' does not share this responsibility as a built-in part of his title; he may be professing or lecturing in a vacuum chamber.
multiple-choice machine developed by S.L. Pressey in the 1920s (33). Stimulus materials are presented in the form of multiple choice questions and answers printed on standard size typewriter paper. The paper, which is inserted into the device, is moved one question at a time for exposure through a mask which allows only one question and its associated answers to appear.

Porter describes the operation of the machine as follows:

"A student reads the question and records the answer of his choice by pressing one of the answer keys which is coded to correspond to the answer alternatives. If the correct answer key has been pressed, the platen advances the paper, making the next question available. If an incorrect answer is given, the next question will not appear and the student has to try again. Counters record the number of correct responses made, and if desired, the device may be set to present a small piece of candy after a predetermined number of correct responses." (36)

A year later, Pressey announced the addition of a valuable innovation:

"When used for the practice of drill material, (e.g., spelling words, language vocabulary, etc.) the device could be adjusted to discard automatically from the list of questions presented all those which have been answered correctly on previous trials." (34).

(parentheses mine)

Writing five years later, Pressey expressed his disappointment in the lack of acceptance of this potential 'industrial revolution' in education. Penning what might be regarded as a classic complaint of researchers, he said:
"The problems of innovation are relatively simple. With a little money and engineering resource, a great deal could easily be done. The writer has found from bitter experience that one person alone can accomplish relatively little and he is regretfully dropping further work on these problems. But he hopes that enough may have been done to stimulate other workers, that this fascinating field may be developed." (35)

As Skinner has pointed out (40), Pressey's machines succumbed in part to cultural inertia; the world of education was not ready for them. Further, Pressey's background of psychological theory had not come to full grips with the learning process. The study of human 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. Why students bothered to learn at all was of little interest. The learning process could be explained completely by means of the theories of frequency, recency, and massed & spaced practice.

The multiple-choice device is primarily a testing machine, depending on previous learning which is reinforced. Pressey's contributions, however, are significant in that:

1. He was the first to emphasize the importance of feedback.

2. He proposed a system in which each student could work at his own pace.

3. He emphasized the need for capital equipment in realizing the objectives of mass education.
4. He conceived of a machine which demanded participation and an active role on the part of the student.

5. His device increased time economy of drill material by dropping items as they are 'learned' (tested as correct).

Recent studies have indicated that if the criterion of learning is recall rather than mere recognition, the constructed response device results in more learning than does the multiple-choice device, even when training time must be limited (13). However, experimental evidence has shown that both methods have shown significant increases in learning efficiency over conventional teaching methods (8).

The Punchboard and Chemical Paper: Although neither automated nor machines, these teaching devices are here considered because of Pressey's interest in them and their resemblance to his multiple-choice device.

The punchboard presents questions with multiple-choice answers in printed form. A paper answer sheet is sandwiched between two heavy sheets of cardboard. Rows and columns of holes in the heavy material delineate the answer spaces. Instead of underlining, checking, or blackening an answer space, the student punches a hole in it. If he punches at the correct spot, the pencil goes through the answer sheet and he knows that he is right. If he chooses the wrong answer, the pencil is stopped by the template under the answer sheet and he has to choose
an alternative answer. In addition to letting the student know when he is right, the answer sheet produces a record of the student's performance, including the wrong answers which are indicated by a pencil mark, and the right answers which are indicated by a hole. (2, 22, 36)

Both Pressey and the Petersons, H.J. and J.C., have made use of chemically treated answer sheets. The answer space for a correct choice was chemically treated to change color immediately when marked with a special ink. This would inform the student that he had made the correct response. Because the marking ink itself was opaque, a record of all the incorrect responses was also made. (36)

This author would propose for the large class of the future testing programs that utilized Royal McBee sort cards. Each student, equipped with his own McBee punch, would enter his answers, coded, on a McBee card. During the class period the professor's assistant would score these cards, item by item, by means of skewer(s), drilling or punching a hole through the center of the entire correct pile for each item. A quick hole count would give each student's score; this is recorded and the card returned to the student at the end of the period. In addition to providing reinforcement through immediate feedback (while there is still interest in the material just learned), the proposed McBee method would minimize cheating and require virtually no machinery.
Of course, the testing method just outlined is analogous to the electrically scored multiple-choice answer sheets typically used in mass testing (e.g., CEEB, GRE, GED, and many achievement tests). However, such tests must be mailed or taken to a grading center where machines are located for scoring. This process is time consuming and does not grant immediate feedback.

Like Pressey's multiple-choice machine, the methods just described are primarily testing devices. Admittedly, by confirming correct responses through immediate feedback and by weakening responses which should not have been acquired, a self-testing machine does, indeed, teach. (40) But this was not the primary requisite of its design. It remained for Skinner to develop the prototype teaching machine designed primarily to teach.

The Skinner Devices: In 1954, Skinner published an article describing his modification of the Pressey device. (39) Using arithmetic operations as contents, he overcame the limitations inherent in Pressey's answering system (each answer represented by one answer key) by employing four answer keys, each capable of using the digits 0 through 9. Thus, students have to compose their answers rather than choose them from multiple-choice answers which may be very similar to the correct answer. The advantages are that such an arrangement pre-
vents accidental conditioning of incorrect answers, and it provides a closer approach to the conditions upon which the answers will be useful in the future (transfer). (36)

By far the most significant contribution by Skinner lay not in his innovations of the device itself, but in the organization of materials presented by the device. In the Pressey devices, groups of questions were relatively unrelated to one another. (33, 34, 35) Skinner, however, presents an organized sequence in which the problems are logically successive and dependent upon earlier materials. (39) Successive steps are so small that if the previous problem has been solved correctly, there is little chance that the present one will not be also.

Of course, this type of subject matter scheduling would be extremely difficult in more amorphous areas than mathematics. Skinner's criterion for using a particular problem as subject matter is simply that the students be able to get it right. If the problem cannot be solved, then it is either the wrong problem, at the wrong place in the sequence, or else it is too large a step from the previous problem. (39)

Although appropriate for arithmetic, spelling, and elementary school curricula, Skinner admitted that this machine was "unnecessarily rigid in specifying form of
response." (40, p. 970) If learning by recall (rather than by mere recognition) is to take place, the student must compose his response rather than select it from alternatives. A further drawback to the multiple-choice machine is that an effective program must contain plausible wrong answers. These are dangerous because they strengthen or at least suggest unwanted forms of behavior.

In an attempt to overcome these problems, Skinner developed the composed response teaching machine which relies on the mature student to compare his responses with those revealed by the machine. This prototype of today's commercially available teaching machines* is the one in use in Harvard University's self-instruction room, discussed in Chapter V.

The typical program consists of 30 items typed in radial (wedge-shaped) frames on a 12" disc. The student inserts the disc, much in the manner that a phonograph record is placed on a turntable. The machine is then

* The Skinner machine presents material on a disc, whereas the products of present manufacturers (e.g., Foringer, Rheem) employ a continuous sheet of paper. Operationally, the major difference is that the drop-out of correctly answered items is extremely difficult on the continuous sheet of paper machines and relatively easy with the rotating disc, or Skinner machine. Conversely, preparation of material by typing, drawing, etc. is much easier on the continuous paper than on the disc.
locked. Items appear one by one in a window, and the student writes his response on a paper strip exposed in a second window. By lifting a lever on the front of the machine, he moves what he has just written under a transparent cover and simultaneously uncovers the correct response. If the two responses correspond, he moves the lever horizontally to indicate to the machine that he has answered correctly. This punches a hole opposite his response on the answer paper and alters the machine so that the item will not reappear when the student goes over the disc a second time (to master the items answered incorrectly). Whether a response is correct or not, the next item appears when the lever is returned to its starting position. A student proceeds in this way until all new items and all items answered incorrectly have had correct responses.

Skinner has stressed that the machine itself does not teach. The student teaches - himself. The machine serves to bring the student into contact with the programmer, and in serving an indefinite number of students, it is a labor-saving device. (40, p.971) Although the machine suggests mass production, Skinner, like other authors (3, 8, 14, 17, 33, 36, 40) stresses the similarity of the teaching machine and the private tutor for reasons discussed in a later chapter.
Programmed Textbooks and "Scrambled Books": Based on the realization that the primary advantages of teaching machines reside in the effective construction of the program itself, Homme and Glaser (in 14, p.103) have developed at the University of Pittsburgh the programmed textbook. Although bound in the manner of conventional books, the interior is markedly different. Each page consists of four or five panels; the sequence of panels is from page to page, rather than from top to bottom of any given page. Each panel demands a response; the correct response is found in the corresponding panel on the next page. After finishing one unit or chapter, the student returns to page 1 and begins another sequence of panels.

The main criticism of the programmed textbook is that 'cheating' is not checked. (Automated machines are equipped with locks that prevent looking ahead or behind.) Drs. Homme and Glaser defend their text on the grounds that:

1. To assert that locks are essential is to assert that other means of controlling a student's behavior cannot be found;

2. We do not really know how damaging to the learning process this kind of cheating is; and

3. In a properly prepared program, cheating is unnecessary and occurs very infrequently. (14, p.105)

Experimentation with several college subject matter programs appears to support the following conclusions:
1. Decreasing the size of the stimulus-response steps in a program results in better learning and retention, up to a point, and

2. Material presented in programmed textbook form results in generally higher and less variable achievement scores on subsequent tests than conventional textbook presentation. (14, p.107)

Crowder (10) has departed from the Skinnerian approach and devised an automatic tutor (non-mechanical) based on his principle of intrinsic programming. Stressing the importance of feedback, Crowder's 'scramble book' allows appropriate corrective action to be taken when a student has learned incorrectly. When an error occurs, the problem is not solved merely by revealing the correct response to the student (as done on teaching machines). Rather, the error must be explained and the learning stimulus repeated.

In the scrambled book, as in the programmed textbook, students check their responses to items with the correct responses occurring on other pages. For example, the question on page 1 of the scramble book may look like this: (14, p.110)

"In the multiplication $3 \times 4 = 12$, the number 12 is called the [product] and the numbers 3 and 4 are called

Page 15 [quotients]
Page 29 [factors]
Page 43 [powers]"

(Let us assume that the student wrongly chooses the answer 'powers' and turns to Page 43.)
Your answer was 'powers'.

We'll get to powers of numbers pretty soon, but we're not there yet. The numbers that are multiplied together to form a product are called 'factors', not 'powers'. Now return to Page 1 and choose the right answer.

(The student now returns to Page 1 and chooses the correct answer, 'factors', thus turning to Page 29:)

Your answer was 'factors'.

You are correct. The numbers which are multiplied together to form a product are called 'factors'. Thus in the multiplication $3 \times 4 = 12$, the numbers 3 and 4 are the factors, 12 is the product.

Is it possible for the same number (same quantity, that is) to be used as a factor more than once in forming a product?

Page 59 Yes
Page 71 No

(This question calls the student's attention to the fact that the factors used in forming a product need not be different quantities. Should a student fail to see this and turn to Page 71, he will find examples of squared and cubed numbers to show that factors may be used an indefinite number of times in forming a product.)

Present experience with scrambled books has been limited to small-scale laboratory studies. The feasibility of preparing material in automatic tutoring form has been demonstrated in such diverse fields as troubleshooting of complex electronic equipment, law, trigonometry, contract bridge, and number theory. (10)
Our discussions to date have been primarily concerned with the variety of self-instruction devices that are largely still in the experimental phase of proving themselves. A few schools have instituted automated courses, and the program at Harvard will be reviewed in a later chapter. A final word is in order regarding the use of self-instruction devices outside the classroom. To date, practically all applications of automated teaching in the non-academic situation have been attempted by the U.S. Air Force.

One of the first attempts to provide a full course unit in which the information-transmission function of the teacher was provided entirely by recorded instruction was made by Newman and Highland at Keesler AFB. According to a newspaper account reported by Lumsdaine (in 14, p.150), several classes were taught a five-day course in Principles of Radio by highly qualified instructors. Other classes were taught the same course by tape recordings and either a workbook or slides. Written examinations of the students in both groups revealed that grades of those taught via tape-recordings ran 'about as high' as those earned by instructor-taught students.

Lumsdaine reports two other instances where the USAF attempted to mechanize their lectures: in training B-47 jet bomber technicians and in teaching English as a foreign language to native personnel in MDAP or NATO countries. (14, p.151)
Test data from the jet bomber technician training showed that the film lectures approximate closely the effectiveness of the live lectures. No data is available for the English training program.

In 1957 the U.S. Armed Forces Institute (USAFI) set up a series of group-study courses consisting of films, textbooks, and study guides and designed for use on bases and installations where instructors were not available. Although the program has been well received by education centers, the author has been unable to locate studies comparing the effectiveness of such presentation with the more conventional course instruction.

As Lumsdaine has pointed out:

"There are many kinds of possibilities for applying mechanized or partially automated techniques in teaching, and some of the same ideas that have given impetus to the development of individual teaching machines may readily find fruitful application in group-instruction situations. This may possibly occur, in the case of many schools, well prior to the time when the applications of individual machine tutoring are regarded as economically feasible and culturally acceptable." (14, p.152)

Briggs (6) reports several instances of the use of self-instructional devices that have been used to train air force personnel in maintenance and troubleshooting of electronic equipment. Because of the large numbers of required procedural sequences and troubleshooting problems, training could not be planned for all situations (and need not be, if transfer is at work). Both multiple-choice devices and complex 'simulators' with built-in
corrective systems were employed. Preliminary research with simpler devices revealed a high degree of transfer from the training situation to performance on actual equipment. However, similar conclusions could not be drawn for the complex trainers before further development and training takes place. Experimental models which could be readily modified in certain aspects would be an aid to further research. (6)

In this chapter we have discussed the variety of designs and uses to which teaching machines have been put. Let us forestall any further considerations of the possible applications of self-instructional devices until we have considered the principles of educational psychology as they relate to our rapidly evolving theory of automated teaching.
CHAPTER III
THE PSYCHOLOGY OF AUTOMATED TEACHING

An Application of the Principles of Educational Psychology to the Theory of Automated Teaching

"It is impossible to educate anyone. All that can be done is to put him in a position where he can find an education. Motivation is the first necessity for this. He must wish to learn and he must wish to develop. He must be curious, he must be eager, and he must be serious."

Barnaby C. Keeney
President, Brown University
There is nothing startling or new in the observation that different types of learning situations call for different teaching procedures. This truism is important, however, to our understanding of the application of self-instruction methods, for there are definite limits to the types of material that may be programmed effectively. It is, then, the first objective of research to determine what types of material can be effectively automated and with what results. Unfortunately, this is the very area in which research has been weakest. Studies to date have concentrated largely on proving that teaching machines can supplement and at times supplant the teacher. But the question of which teacher (or which area of a teacher's curriculum) should be supplant has remained unexplored.

Two things are required of us before we attempt to answer this question. They are:

1. An understanding of the principles of psychology at work in the self-instruction process; and

2. An understanding of the nature of the subject matter belonging to a course of study.

The present chapter deals with this first prerequisite, which, although discussed in part by many researchers, has not appeared heretofore as a composite body of knowledge. The next chapter will consider the nature of programmed material and the principles of effective programming as
practiced at the present time. Such considerations are based on an understanding of the concepts used in educational psychology and discussed in this chapter. The most important of these are:

1. Feedback
2. Reinforcement
3. Motivation
4. Transfer
5. Association
6. Attention and Perception

Feedback

Although closely related to reinforcement, and hence motivation, feedback is here treated separately because of its split personality. For there are two types of feedback inherent to the process of automated teaching:

1. Teacher feedback, which grants the teacher a continuous record of the students' progress, and thus affords the opportunity to clarify presentation through the rewording, addition, or change in sequence of items; and

2. Student feedback, which requires an active role of each student, granting in return immediate knowledge of results (reinforcement) and thus permitting instant correction.

Teacher Feedback: This phenomenon might be compared to the instance of two rats conversing in a Skinner box. The rat leaning on the bar is saying to the other rat: "Boy, do we have this guy conditioned. Every time I press the bar down, he drops a pellet in." In other words, the rat controls the experimenter's behavior. Likewise, in the
student-teacher (programmer) situation, the students' responses become the teacher's stimuli, and the teacher's resulting responses become the student's stimuli.

When a number of students have difficulty with a part of the program, the programmer must correct this. The students' answers reveal ambiguities in items, gaps in the program, and erroneous assumptions regarding background preparation. The error rate thus indicates when a program is progressing too rapidly, when additional prompts are necessary, or when the programmer should try new techniques. According to Holland:

"Such careful tailoring of material to fit the student is impossible with most teaching techniques. With teaching machines, as in no other teaching technique, the programmer is able to revise his material in view of the students' particular difficulties. The student can write the program; he cannot write the textbook." (18, p.13)

A revision of the Harvard self-instruction program in psychology based on students' errors (teacher feedback) lowered the error rate from 20% to 11%, decreasing simultaneously the amount of time required for program completion. (18, Table II)

**Student Feedback:** Three characteristics of this phenomenon are (1) an active response by the student, (2) immediate knowledge of results, and (3) instant correction.

The desirability of active student response in the learning situation is obvious and needs no defense. In
the classic experiment involving teaching of the military phonetic alphabet reported by Hovland, Lumsdaine, and Sheffield, the 'participation' or active-practice group learned more quickly than the passive-learning group and reached 'near-perfect' criteria as the amount of active participation increased. (21) Of particular interest to the field of automated teaching is the observation that the advantages of active response were least when least needed (i.e., with brighter, highly motivated students) and greatest when most needed (with slower, less motivated students). The active response required by self-instruction devices would seem to exert a leveling effect on classes.

Whether we can transfer these findings from a 'rote-material' paired-association situation to the more complex learning situation usually found in automated teaching is open to question. This author believes affirmatively and feels that useful predictions can be based on the same assumptions about associative processes that seem useful in accounting for the acquisition of simpler associates. Furthermore, mastery of these simpler associations must often precede the more complex forms of concept formation and association. As Lumsdaine has noted:
"Regardless of theoretical predilections, the results may also seem not without interest to educators who are impressed with the enormous fund of basically paired-associate response acquisition required in mastering, for example,... foreign languages, medical terminology, or the nomenclature of almost any technical subject matter — paired-associate prerequisites that are indispensable to later conceptual manipulation involving the acquired terms." (14, p.157)

Michael and Maccoby have investigated the active vs. passive response in a study requiring written responses to subject matter dealing with defense against atomic attack. Active response was required at intervals between sections of film exposition by the insertion of question and immediate answer sequences. Results showed that the higher percentage of correct answers earned by the active response group were wholly attributable to specific practice effects rather than to motivational benefits accruing to items not practiced. Further conclusions of the study indicated that:

1. the largest single factor in determining the efficacy of the active response procedure was the provision of feedback correction through giving the correct answer after each question had been responded to by the students (italics mine); and

2. covert (subvocal) response was about as effective as overt written response. (29)

So much for the importance of active student response in the learning situation. The remaining characteristics of student feedback are: immediate knowledge of results
and instant correction. The primary purpose of such feedback is reinforcement; it is in this concept that automated teaching makes its greatest contribution to the learning process.

**Reinforcement**

Immediate reinforcers are teaching devices which attempt to increase efficiency in the learning process by automatically presenting the student with a reward or reinforcement immediately after he has made a correct response (and, conversely, by correcting errors immediately - before they become 'learned').

Technically, a reinforcement is any environmental event which strengthens the behavior it follows. In teaching devices, the reinforcement is a direct consequence of the student's behavior, usually in the form of confirmation of the correct answer. (36)

The effects of reinforcement are complicated; it serves not only to confirm the subject's preceding behavior, but also to maintain the motivational level. (16) Conversely, when we know what a person's motivation is, we usually can predict how we can effectively reinforce his behavior. When motivation is intrinsic and depends in some way upon the nature of the task, relevant reinforcement is provided by giving the learner
knowledge of the results. (14, p.28) Experimental evidence offered by Osgood (31), Hovland (20), and Woodworth (45) has indicated that reinforcement should be positive, constructive, and immediate. Only in automated teaching can reinforcement be immediate and personal.

In the usual classroom situation, teachers are too busy presenting material to concern themselves with reinforcement. Reward and punishment are more realistic terms for the average teacher; we have, however, defined reinforcement more broadly. Even in the narrower sense of equating reinforcement with reward, many teachers use rewards that are totally unrelated to the learning task. Reward is effective only in terms of its association with the behavior being rewarded. Yet both Pressey (33) and Foringer (12) have employed dissociated rewards in their teaching machines (candy and marbles, respectively).

Thorndike prefers the terms 'satisfaction and annoyance' to reward and punishment. Thus, a high density of correct responses is satisfying. Conversely, material which generates errors is punishing (18), or annoying. Laboratory experiments have shown that punishment lowers the rate of the punished behavior. (18) In the Harvard studies, Holland has noted that "students stop work when the material is so difficult that they make many errors."
Furthermore, they become irritated, almost aggressive, when errors are made. (18)

The traditional reinforcers in psychological experimentation have been food, water, and electric shock, which serve well for animals. Since it is unethical to shock, starve, or dehydrate humans, other reinforcers have to be used with teaching devices. Skinner has suggested that exploratory and manipulative activities are reinforcing enough to keep a student busy with the device. (39) Woodworth, however, reports that an organism's curiosity becomes satiated by prolonged exposure to novel situations. (45, p.671)

Any teaching device used almost continuously would face the problem of satiation. One method of avoiding satiation would be to mete out reinforcement in small doses. Another method would be to have alternate reinforcers available. Skinner suggests several alternative reinforcers: social approval, desired activities, and as a last resort, aversive stimulation. (39) Pressey (33) and Foringer (12) have preferred physical rewards, as noted earlier.

Most researchers of the teaching machine, however, contend that knowledge of one's correct responses is the best reinforcement possible. (2, 18, 36, 40) And experimental evidence has amply demonstrated that knowledge of the correctness of one's responses improves performance.
of a task. (45, p.686) However, as Porter points out,

"Knowledge of results is a descriptive term which refers solely to a particular kind of sensory feedback, and not to the reinforcing value of the feedback. The conditions under which this kind of an event attains and maintains reinforcing value are little understood, but if mechanical teaching devices are to be used successfully, educators will have to discover and use the contingencies which are available and most effective in making knowledge of results reinforcing." (36)

In summary, reinforcement is the result of feedback and serves to sustain motivation. Reinforcement should be positive rather than negative (satisfaction rather than annoyance), related to the learning task, personal wherever possible, and immediate rather than delayed, in order that (a) the trainee's motivation not lag, and (b) errors not become learned. This is accomplished in the automated teaching machine by so structuring a progressive sequence of learning material that the probability of error is minimized, and by informing the trainee immediately of his results so that correct responses will be rewarding and incorrect ones will be corrected.

Motivation

Osgood presents conclusive evidence that performance improves as motivation increases. (31) Thus the most effective training program would be one that creates a maximum of motivation. The question of what elements motivate
a student and how they can be maximized is not an easy one; motivational variables are probably the most elusive concepts with which psychologists work.

As already noted, motivation and reinforcement are highly interrelated; immediate reinforcement serves to sustain motivation. But such an answer is deceptively simple. How, for example, can we assure ourselves that student feedback will be rewarding? In other words, how can we guarantee that a student's error rate will be motivating? Further, what other motivational variables are at work in the automated teaching situation and can we control them?

In his chapters on curriculum design, Brameld notes that student motivation depends on three factors:

1. Degree of challenge
2. Degree of responsibility
3. Degree of immediate usefulness of subject matter.

(5, Chap.8,9)

Our discussion of the questions raised above will take place within these three areas outlined by Brameld.

Degree of Challenge: A clear split exists in the literature on the question of how challenging the material programmed for self-instruction should be. On the one hand Galanter (14) advocates a program which will train students to detect errors 'planted' in the program and avoid errors in their own thinking, but he emphasizes that this should
be done without the commitment of errors in a student's written responses to the program - in short, without having material too difficult (challenging).

"We see no reason to suppose that a program that aids in the commission of errors can be valuable. Errors that the student makes only serve to provide information to the teacher. We need the information but not the errors. We retain some errors only because we believe that different students require different programs, and the errors serve as an economical signal. When the student makes an error, the teacher reads it as, 'I don't understand; do something to help me!'" (14, pp.6,7)

Thus, on a self-adjusting machine, when error rate is high, the machine returns to earlier material; conversely, a low error rate tells the machine to skip some repetitive or exemplary material and move ahead. We might also infer from Galanter's argument that the need for errors as teacher feedback diminishes as a teacher improves the program (based on past students' errors). The only error desirable now is the student feedback error that reveals individual difficulty in understanding material.

The error probability should remain around some optimum value. For verbal or symbolic material, Galanter suggests a 10% or less error rate (14, p.6). This is in agreement with the Harvard studies, where the revised psychology program yielded an 11% error rate (18, Table 2). Similarly, in an experiment sponsored by Harcourt, Brace, & Co., a program of English grammar tested on 30 seventh
grade slow learners (I.Q. scores 75-90) produced a 9% error rate. For skilled action training like motor tracking or writing, a higher error rate is permissible; perhaps 15 to 20%. (14, p.6)

Clearly, the reduction of error probability is accompanied by a reduction in the degree of challenge. The student who yearns to sink his teeth into the meat of a subject will find little challenge in being fed strained baby food; further, his teeth may never develop.

In contrast to the low error probability arguments of Galanter (14), Holland (18, pp.11,12), and Skinner (40, p.975), Smith notes the possible advantage of a higher error rate, reflecting greater challenge:

"There may be some advantage to inducing some errors. Apparently, in an imperfect program motivation runs high, so much so that even 'honest' children try to cheat. It seems as though the possibility of failure enhances the reinforcing effect of a successful response. Thus, failure on some items may contribute to the effectiveness of the learning." (14, pp.91,92)

Further argument in defense of error is advanced by Ellis (11), who cites experimental evidence to prove that the preparation of false statements and errors do not necessarily tend to develop and establish errors. He calls particular attention to Dunlap's gamma hypothesis, where deliberate practice of an error is sometimes the only way to master it:

"Since errors cannot be avoided, they must on occasion be mastered as errors. Then they can be avoided." (11, p.208)
Although it should be an easy matter to determine whether or not those program items accompanied by the highest error rate were the ones best learned, no attempt to apply the gamma hypothesis to automated teaching theory has yet appeared in the literature.

Skinner defends low error probability programming against those who feel that a student will never develop his thinking skills in creative concept formation with the following:

"What sort of thinking does the student learn in struggling through difficult material? It is true that those who learn under difficult conditions are better students, but are they better because they have surmounted difficulties or do they surmount difficulties because they are better? In the guise of teaching thinking we set difficult and confusing situations and claim credit for the students who deal with them successfully." (40, p.975)

The teacher-turned-programmer usually finds it difficult to construct items that 'give the point away'. Yet, as Skinner contends, there is nothing more effective in the teaching process than giving a point away.

"Making sure that a student knows he doesn't know is a technique concerned with motivation, not with the learning process. Machines solve the problem of motivation in other ways. There is no evidence that what is easily learned is more readily forgotten. And if this should prove to be the case, retention may be guaranteed by subsequent material constructed for an equally painless review. (40, p.975) (Italics mine)

What are the other ways by which machines solve the problem of motivation? If not by the challenging
nature of the material, perhaps by one of the other factors cited by Brameld as a determinant of motivation.

**Degree of Responsibility:** As noted in the preceding chapter, no teaching machine actually teaches. Rather, the machine presents material so structured that the student becomes his own teacher. The degree of responsibility of each student is thus raised significantly over that found in the usual classroom presentation. The treatment of a student as an individual, responsible for scheduling his own study time, should also provide more motivation than the type of schedule where students are herded impersonally from one lecture room to another. We must not, however, overlook the effects of group membership and the motivation that comes from friendship ties in the classroom situation. Perhaps the self-instructional student must be more mature, more the individualist.

Another consideration of how motivation is affected by responsibility: Although the marks (grades) assigned to students are traditionally regarded as a means of motivation, in the realm of automated teaching the grade is meaningful only as an indication of **how far** a student has gone, since machine instruction assures mastery of every stage. (40, p.976) The responsible student now has the opportunity to cover course material at his own rate, and can thus take more courses than the slower or less respon-
sible student (not the same). The automation of instruction, coupled with the student's exercise of responsibility could lead to a reduction in the 'time in grade' requirements at most schools. Degrees could be earned by students upon completion of required courses without having to spend a specified number of years in residence.

Finally, the concept of level of aspiration is closely related to the factor of motivation. Gagne and Bolles (16) note that the difference between the performance an individual thinks he can do and what he actually accomplishes has been found to be an important motivational variable. Here, again, the responsibility is on the student to set realistic personal goals that are high enough to encourage learning and low enough to be met. Again, the optimum error probability built into the program will aid the responsible student in defining and meeting such goals.

Degree of Immediate Usefulness of Subject Matter: Coupled to the general rule that motivation facilitates performance (31) is the qualification that the motivation should be relevant to the task. Perhaps the strongest and most desirable motivation possible is that the task itself be interesting and the material relevant to personal goals. Successful task completion and the application (transfer) of newly acquired learning to real life problems provide
very real motivation, especially when the student is ego-involved, so that pride in success at the task becomes a goal. Desire to succeed appears, in fact, to be a highly dependable source of motivation for the learning situation. (16)

In contrast to this intrinsic form of motivation, there are extrinsic factors which may be related to the nature of the learning situation although not a built-in part of the programmed material itself. Among these are competition and the desire to please one's superiors. (16) These are delicate issues, however, in that competition often causes anxiety over possible failure, and desire to please one's superiors can easily result in fear of ability to do as well as fellow trainees. Emotional tension is thus aroused and learning is more difficult.

Skinner suggests another possible extrinsic motivational factor: the fondness for gambling. (40) Perhaps we should not overlook the similarity between the teaching machine and the 'one-armed bandit'!

In summary, motivation is an elusive concept which, nevertheless, can show us a few principles to apply to the theory of automated teaching. Motivation depends on the degree of challenge and immediate utility afforded by the subject matter as well as the amount of responsibility which the teaching situation allows the student. (5)

Maximum motivation may be achieved when:
1. An optimum probability of error exists in which that motivation lost because the material is easier and therefore less challenging is gained in the form of satisfaction (reinforcement) in achieving standards of mastery. (11, 14, 40) This level of probability of error is optimally about 10% for verbal and symbolic skills (40) and 15-20% for motor skills (14).

2. Such optimum levels of error probability may be maintained by one of two methods: (1) through pre-testing of programs (so that teacher feedback is eliminated, leaving only student error feedback that indicates individual non-comprehension or error rather than general ambiguity of items); and (2) self-adjustment of machine (servomechanism) so that high error rate will return a student to earlier material and low error rate will drop repetitive items.

3. Like the reinforcement which sustains it, motivation should be intrinsically relevant to the subject matter. This is easiest when the material to be learned is ego-involving and permits near-total and immediate transfer to practical everyday tasks. (16)

4. Such extrinsic factors as competition, the desire to please superiors, etc. should be kept at the highest level possible before emotional tension begins to take energy from the learning process. (16) Other extrinsic factors, such as the novelty of automated teaching and the gambling process at work, may play a smaller role. (40)

5. The increase in responsibility resulting from individual rather than group treatment of students should be accompanied by the student's realistic establishment of levels of aspiration (16), and by self-paced coverage of course material in as rapid a manner as each student can optimally work (40). In this manner superior students will not be held back and thus penalized by slower students (33).

Transfer

As previously noted by Thorndike, learning may be said to occur only when behavior is altered (41). But
where is behavior measured? Experimental evidence by Krueger on overlearning shows that performance during the learning situation does not necessarily mirror how much has been learned (26). Studies by Kendler have shown that problem solving is intimately related to one's ability to generate appropriate 'response-produced cues'. These cues mediate the transfer from one situation to another (23). Thus, we must measure behavior of the trainee not at the point of learning, but rather at the point of transfer, at which the learning is applied and behavior may be shown to be altered.

As Ellis (11) has pointed out, overlearning must take place if transfer is to be effective:

"With a recognition of the fact that training is of value only in proportion as it transfers to life situations and that transfer is not automatic but depends on the person's ability to recall and use what he has learned, it becomes evident that material which is not well learned is not likely to be used effectively when conditions arise where it could be used if mastered. The study of forgetting has shown, furthermore, that unless material is overlearned, that is, learned beyond the point of perfect recall, it is ordinarily soon forgotten so that it cannot be recalled accurately without assistance. Thus, even if material could be transferred to a situation just after the learning has taken place, it is quite likely to be forgotten, so that at a later date recall and use would not be possible - unless it has been overlearned." (11, p.148)

Skinner has been already quoted as saying:

"If machine instruction assures mastery of every stage, a grade will be useful only in showing how far a student has gone... Given enough time, he will be able to get an A; and since A is no longer a motivating device, this is fair enough." (40)
Holland states his case in similar terms:

"Behavior is learned only when it is emitted and reinforced ... while working with a machine, the student necessarily emits appropriate behavior and this behavior is usually reinforced since the material is designed so that the student is usually correct." (18, p.5)

And, as shown in earlier chapters, both Skinner and Holland have considered recall (write-in answers) to be the measure of learning, while Pressey (33, 34) favored recognition (multiple-choice) as sufficient criterion of learning.

But all three investigators seem to be ignoring the question of transfer. The satisfactory completion of a self-instruction program is no more evidence of learning than is the completion of a book an indication of the understanding of its contents or the ability to apply them to real situations.

In an investigation of the military application of automated self-instruction, Gagne and Bolles (16) have distinguished between the three primary types of tasks for which teaching machines have been employed:

1. Identification
2. Following procedures
3. Concept formation

(Motor skills, once important in military and industrial applications, have become less important with the increasing use of automatic equipment and prefabricated construction; the repair function is now centralized).
In tasks involving simple identification, learning can often be judged by performance during self-instruction. These tasks present little or no difficulty to the trainee on the job if he has mastered the items on the machine. (For example, in transferring knowledge of descriptive material about stock machine parts to their identification in the stockroom; or in identifying enemy aircraft from their photographic description on a self-instruction program.) The behaviorists have attempted to explain this type of learning in terms of paired-associates. However, in discussing the importance of intra-task similarity to transfer, Gagne and Baker suggest that the empirical evidence obtained on response similarity in paired-associate learning is quite inadequate for significant conclusions to be drawn concerning the effects of this factor on single associations in learning (15).

The two remaining types of tasks (i.e., following procedure and concept formation) probably require a more complex type of transfer; experimental evidence is lacking. We would be foolish, however, to assume that learning has taken place short of its demonstration in application in the job situation. The difficulty here is that most academic classroom learning is not for application on specific tasks that rarely change, but rather for performance on a variety of tasks in a variety of situations. Isn't the very purpose of most learning the cultivation
of a student's ability to transfer? Perhaps that subject is most valuable which grants the greatest amount of transfer to real situations in everyday life. Thus the concept of transfer and the problem of effective programming are inextricably bound. As Kendler notes:

"If we knew a bit more about transfer, we could have more confidence that good programming would become a scientific technology instead of remaining an art." (23)

Conversely, it is this author's hope that the gradual evolution of a working set of principles for effective programming resulting from the present learn-by-doing approach will contribute to our knowledge of the factors at work in the process of transfer; this could be one of the greatest contributions of our evolving theory of automated teaching.

Finally, experiments show that students who are prompted during learning do better both in practice and in the transfer situation. Kimble and Wulff compared slide-rule performance by prompted and unprompted groups of students and found that those who received 'prompt questions' did better both during practice and in transferring to similar items. (24)

In summary, the concept of transfer must be regarded as the criterion for learning. Learning may be said to be efficient if it leads to a high level of performance in the transfer situation. (16) Where little or no
transfer is required (i.e., tasks involving identifica-
cation), performance in the self-instruction learning
situation may be sufficient measure. (15) Overlearning
beyond the point of perfect recall may be required to
overcome the effects of almost immediate forgetting. (11)
However, where a greater degree of transfer is required
(i.e., tasks involving following procedure and concept
using), learning must be measured in the transfer situ-
ation (on the job). (16) For only here will behavioral
changes become apparent. (41,42) It is precisely here,
however, that the behaviorists (18, 33, 40) seem to have
overlooked both the need for overlearning and the impor-
tance of transfer criteria for learning.

Association

The obvious explanation for the behaviorist's failure
to apply the concept of transfer to the assay of learning
is his conviction that learning is implicit when a response
to the stimulus item has been conditioned. In other words,
in the behaviorist's theory of association, conditioning
and learning are synonymous - if the correct, or appro-
priate response occurs consistently whenever the stimulus
situation appears, learning has taken place.

To measure learning, we measure performance (which
reflects behavioral changes). But not performance in the
transfer situation. The behaviorist measures it during
the learning process itself (conditioning) by such overt
characteristics as:

1. Accuracy of response (changes in error rate)
2. Speed of responses
3. Amount of energy output
4. Introspective feelings of effort
5. Strength of response (37, pp.277,278)

Indeed, the learning required in many everyday situations can be explained on the basis of the theory of association. Thus, we learn a person's name by looking at the person and saying the name several times, aloud or subvocally. Or we learn that an object is hot or sharp by our first (often unhappy) encounter with it. Unless we continue to burn or cut ourselves whenever confronted with these objects, transfer has taken place. And reinforcement (in this instance, avoidance of pain) has provided motivation for learning.

Thus are the concepts of transfer, reinforcement, and motivation interrelated as they apply to the learning situation, whatever theory we accept as explanatory. As already noted, the behaviorist's explanation of these concepts is only partial. Ruch (37, p.277) advances as one possible reason the fact that most research on learning has been concerned with the learning of either facts or skills. With such subject matter (and especially in experimentation with animals), the experimenter has had no choice but to set up extrinsic rewards in order to induce behavior and hence learning. Yet, as indicated in our discussion of motivation, learning that has its
primary value in the transfer situation (and this can apply to 'rote' (memorized) material (e.g., spelling words, multiplication tables) as well as 'meaningful' material) is likely to be motivated by intrinsic factors that are inherent to the subject matter and the rewards offered by the transfer thereof. As noted by Ruch:

"Learning that is motivated intrinsically goes far beyond factual knowledge and skills to include new attitudes, broad understanding, and strong convictions that actually make a difference in subsequent behavior. This is the kind of learning that schools are becoming increasingly concerned about fostering, as opposed to giving children only knowledge, which might or might not ever affect their behavior." (37, p.277) (italics mine)

Not only does the behaviorist fail to recognize that intrinsic motivation and transfer are mutually inclusive concepts and rarely exist independently, he fails to recognize that the complexity of stimuli that one encounters in real life situations seldom resembles the simple stimulus presented in the classroom. This discrepancy need not be great to affect transfer. Pavlov himself noted that even the presence of a fly in the conditioning chamber caused disassociation of the conditioned response with its stimulus. Obviously transfer cannot be measured when the learner cannot associate a new task with simpler S-R tasks that he has learned.

Here the field theory of the Gestaltist comes to our rescue. For here learning is interpreted in terms
of the 'cognitive processes': emphasis is placed on the meaning which a situation conveys to the individual in determining the nature of his response. Nor is this response merely performance in the learning situation, for now transference has become fully meaningful:

"When an individual suddenly 'sees' the solution to a problem, it is because he has reorganized his perception of the situation and found new meaningful relationships in it. In other words, he has created new field properties in his perception of the problem."

(Ruch - 37, p.277)

A further concept borrowed from the theory of association is relevant to the construction of automated self-instruction programs: fading. Similar to the principle of gradual progression (small-steps between items, each item slightly harder), the concept of fading involves the gradual withdrawal of stimulus support as the correct response becomes learned (conditioned).

(18, pp.6,7) Those 'crutches' that help in identifying or explaining the stimulus are slowly removed, leaving the naked stimulus to elicit its associated (paired) response. This concept is illustrated below in several items chosen from the program used in teaching graphic arts in the Boston University experiments conducted by the author. Consider how the explanation of letterpress printing is developed:
Original stimulus item; response either present ('letterpress' stimulus & 'raised' response) or implicit in order of presentation ('flat' & 'engraved'), a crutch, or prompt mechanism.

Prompt given as paired-associate with original stimulus ('letterpress') and required as response.

Learning of paired-association now complete; stimulus word required. Prompts withdrawn.

Review (overlearning) of old material in introducing new. Paired-association now in original order.

1. Printing can be accomplished from three types of surfaces: raised (relief), flat (planar), and engraved (cut out). Letterpress printing refers to the raised process, planography (or lithography) refers to the _______ process, and intaglio refers to the _______ process.

2. In the letterpress, or raised printing process, ink is transferred from the _______ surface of type (typeface) to a paper surface.

5. Linoleum block printing and rubber stamp printing are examples of the raised (relief), or _______ process.

16. Returning now to the letterpress process, which prints from a _______ surface, there are three major types of presses: platen, cylinder, and rotary

In summary, the theory of association which forms the backbone of behaviorism is inadequate in offering realistic criteria of learning through oversimplification of the learning process. Although the conditioned response offers an adequate explanation of simple learning tasks involving mere identification (such as items above), it falls down in explaining the more difficult situation where intrinsic motivation, transfer, and reinforcement are so integrally interrelated. These more complex tasks can
better be explained in terms of Gestalt field theory. It is unfortunate that virtually no work has been done in the area of automated teaching by the Gestaltists, who have contributed so heavily in other areas of education.

**Attention and Perception**

The concepts of attention and perception are dealt with jointly, since attention to the teaching material presented is prerequisite to its organization and interpretation (perception) in the mind of the learner.

Gagne and Bolles have found it convenient to regard attention as a *state of readiness* and an *intent to learn* (16). We recognize motivation at work in the latter. These categories correspond to the three kinds of attention listed by Ruch:

1. a bodily (postural) adjustment; sense organs alert
2. an awareness of conscious experience
3. a set toward action (readiness to respond)

(37, p.237)

Ruch's first two categories are states of alertness and depend largely on the nature of the physical stimuli presented (e.g., size, intensity, repetition, movement), whereas his third category is largely based on the student's intent to learn. Here social conditioning and relevance of material to personal needs are necessary to explain attention.
Gagne and Bolles note that none of the items in an extensive bibliography on attention deal with the relationship of alertness to either learning or transfer (14, pp. 31, 32). They conclude that we know little about alertness in learning and would do well not to make predictions concerning it.

On the other hand, intent to learn has been examined by Postman and associates in their studies of incidental learning. They conclude, contrary to popular belief, that intent to learn is not always, or even usually, an important factor in learning. While some types of material are learned slightly better by those with intent to learn, the incidental learners sometimes perform equally well. Furthermore, associative interference is often reduced under incidental learning conditions, thus actually making the retention of incidentally-learned materials superior to intentionally-learned ones on some occasions (32). We must recognize in these studies, however, the distinction between intent to learn, an attention factor, and desire to succeed, a motivational factor. This distinction is often difficult.

Although the teaching machine will probably never influence our intent to learn to any degree (beyond the satisfaction of curiosity aroused by the new method of presenta-
tion*), it should certainly favor our alertive attention and subsequent perception, contrary to the bibliography reported by Gagne and Bolles (14, pp.31,32). Conventional classroom presentations regard the student as a passive receiver that will absorb material without any action required. An evaluation of the general effectiveness of lecture courses will reveal that this is not so. The automated program offers an alternative presentation where both attention and action are required. Holland compares the teaching machine to usual classroom exposition:

"Ineffectiveness of classroom techniques is often credited to 'inattention' or poor 'concentration'. If a discrimination is to be learned, adequate observing behavior must first be established. This observing behavior, or, speaking loosely, "attention", is subject to the same forms of control as other behavior ... When the student becomes very 'inattentive' in the classroom, the material flows on; but with a machine, he moves ahead only as he finishes an item. Lapses in active participation result in nothing more than the machine sitting idle until the student continues."

(18, p.8)

Attention is most effectively achieved on self-instructional devices because many items can be answered only by a careful reading of the item. The programmer creates

* for example, the Harvard studies reported that enrollment in the automated course (Introductory Psychology) more than doubled from 1959 to 1960. However, this huge increase in 'intent to learn' could also be explained by the shift of class meeting hours from Mon., Wed., & Fri. (1959) to Tues. & Thurs. (1960). Even if we could establish that the machine alone was responsible, it is doubtful whether all courses if automated would enjoy similar attraction of students, once their curiosity had been satisfied.
emphasis in certain areas by his choice of which part of an item is omitted (written response).

Similarly, Skinner compares the teaching machine to textbook exposition:

"The machine has already yielded important relevant by-products. Immediate feedback encourages a more careful feeding of programmed material than is the case in studying a text, where the consequences of attention or inattention are so long deferred that they have little effect on reading skills. The behavior involved in observing or attending to detail - as in inspecting charts and models or listening closely to recorded speech - is efficiently shaped by the contingencies arranged by the machine."

(40, p.975)

On the other hand, Pressey warns against the possible drawback of the teaching machine when used with superior students. In their usual reading habits, such students are accustomed to skimming a page for major ideas; their views are wholistic. Indeed, one of the characteristics of the superior student is his ability to abstract the important and discard the rest. Perhaps in requiring this student to succumb to the short-step, easy detailed programming that automated teaching necessitates, we are sacrificing far greater abilities than those we offer as substitutes. (14, pp.192,193) It is for this student in particular that the Gestalt psychologist must come to the aid of automated teaching theory - and spare the forest as well as the tree!

In summary, self-instruction devices provide far greater control over the student's attention than the normal class-
room situation by requiring alertness and active response. Perception is similarly controlled in that the need to recall material presented in earlier items necessitates the organization of material into personally meaningful configurations (through their equation with needs, goals, and when necessary, mnemonic devices). There may be some danger that the superior student will lose (or not develop) his ability to abstract and synthesize when subjected to automated teaching. It is in this area of attention and perception, as well as association, that Gestalt field theory can be profitably applied; this has not yet been done.
CHAPTER IV
PRINCIPLES OF PROGRAMMING

Considerations Regarding the Construction of Items and Sequences for Self-instruction

"American educational philosophy, largely grounded in the James-Dewey-Kilpatrick tradition, has taught that we learn best by mastering problems. Formal education should duplicate the nature and the human nature of everyday life by offering the learner the opportunity to face realistic problems and to solve them. While this principle has made considerable difference in education below the college level, with some exceptions its implications have not been carried out at the college level."

J. P. Guilford
Without a doubt the most difficult area of automated teaching is program construction, or programming. A self-instruction program is only as good as its author. Since the knowledge of effective methods of programming can be applied to the teaching efforts of school and industry alike (whether in classroom or on self-instruction machines, scramble books, or punchboards), some time should be spent in collecting and reviewing the accepted procedural steps in preparing a program. Many of these principles are grounded in the psychology of learning; others result from the serendipity of an ingenious programmer.

One of the first and largest problems that a programmer must overcome is the inclination to apply past experience in test construction to the design of the automated program. Whereas a test question should be discriminating and produce some incorrect answers, the ideal self-instruction item should yield perfect or near-perfect scores. Skinner notes that the customary classroom practice has been to maintain the necessary anxiety by inducing errors.

"In recitation, the student who obviously knows the answer is not too often asked; a test item which is correctly answered by everyone is discarded as nondiscriminating; problems at the end of a section in a textbook in mathematics generally include one or two very difficult items; and so on. The teacher-turned-programmer may be surprised to find this attitude affecting the construction of items. For example, he may find it difficult to allow an item to stand which "gives the point away"." (40, p.975)
As already noted, Skinner is not concerned with maintaining anxiety beyond the normal amount present in a situation of anticipation.

Schutz also warns against the transfer of test construction experience to the self-instruction situation:

"Although I think that experience in test construction proves valuable in writing programmed material, traditional psychometric theory does not apply.... Instead of writing plausible foils and distractors, the programmer is concerned with including enough "specific determiners" in previous questions to insure that the student will answer the subsequent item correctly." (38)

Galanter notes that a successful programmer must (1st) be thoroughly familiar with the content of the subject matter to be taught, (2nd) have more than a superficial knowledge of learning theory, and (3rd) know the techniques of test construction (17). Smith recommends another prerequisite, observing that practically all the successful programmers with whom he has worked were characterized by an inverted style of thinking:

"The inverted thinker focusses so intensively upon a stimulus configuration, either perceptual or conceptual, that the differentiation process appears to continue far beyond that of the normal. Such a person tends to be analytical, deductive, methodical, perfectionistic - in short, the classical or Jungian introvert. In thinking style he is diametrically opposite to the extrovert who tends to skim over the conceptual surface of life, to think elliptically, synthetically, inductively."

(14, pp.92,93)
He concludes that the selection of personnel who can write programs effectively may well be facilitated by using a measure of extraversion-introversion.

But our primary concern is in developing criteria that will help us to prepare programs rather than to locate good programmers. The programmer can, after all, correct the inadequacies of his program by studying the responses of his pilot study group of students and then refining the size, order, and content of his program through a series of successive approximations. Such a process clearly indicates that there is more art than science to programming at present. (The most common program errors, however, are of two types and are simple to revise: either the programmer has included a number of irrelevant items or he has tried to move too rapidly (38).)

Nevertheless, we can benefit from the experiences of pioneer programmers. Several have stated their writing procedure in terms of general principles that reflect a movement toward programming as a technique with the predictability of science. Such general principles will be of value to us if, for example, we can pass them on to communicators in business and industry with the result that their messages are better understood and acted upon ('learned', since voluntary behavior has changed).

Smith outlines eight principles of programming, presented here in natural sequence (14, pp.91-102). With ex-
amples taken from the Boston University study, the pro-
cedures outlined here have been followed to some degree by
all researchers of automated teaching.

Although this presentation follows the outline advocated
by Smith, his classification of items (e.g., review items,
 fading items, prompt items, etc.) corresponds to those em-
ployed by Beck (14, pp.55-62), Holland (18), Schutz (38),
et al.

I. Define precisely the desired behavior and the form or
forms which it must take. This statement of objectives should
distinguish what type of learning is desired (e.g., facts,
skills, concept formation, attitudes and values, procedures,
etc.) and what the boundaries of the area to be learned are.
For example, the Boston University study defined the objectives
of the one-week segment under examination as follows:

To develop the ability of students to recognize
and describe the three major methods of printing and
the type(s) of presses used in each; to know how the
printing surface is prepared for each process; to know
the advantages and disadvantages of each process and
thereby know which to select for any given printing
job.

II. Determine the steps to be learned which, when summated,
will comprise the behavior. Again, from the Boston University
study, each student would be required to:

Learn to associate each method of printing with
the type of surface that accomplishes the printing;
learn to identify the presses by their operational
differences; learn which type of composition is used
on each press (and in each process) through associa-
tion with their operational differences; learn how
these differences affect their application to a spe-
cific printing job.
III. Introduce the concept and the nature of the relationship between concept and operation. Define all terms to be used.

Introduction by definition: a non-technical definition is presented and followed in the same frame (or next immediate frame when both can be viewed simultaneously) with an example, part of which the student can formulate. E.g.,

29. Typesetting is known as composition. When done by hand, each character of type has been separately cast. In machine composition, however, an entire line of type is cast. Thus the machine is known as a ________.

30. A linotype machine is used for the typesetting, or composition of practically all commercial letterpress printing. It has the advantage of speed and an even, or justified, right hand margin.

31. The typewritten letter does not have a justified right hand margin as a linotype-composed letter does.

Introduction by example:

1. Printing can be accomplished from three types of surfaces: raised (relief), flat (planar), and engraved (cut out). Letterpress printing refers to the raised process, planographic (or lithographic) refers to the flat process, and intaglio refers to the engraving process.

Introduction by anticipation:

19. Stereotypes are used on rotary presses, whereas type locked in a chase is used in the other two letterpress processes. (The stereotype is usually bent to fit around a cylinder).

21. The difference between a cylinder press and a rotary press is that the rotary prints from a curved plate known as the stereotype, whereas the cylinder prints from a bed of type locked in a chase.
Introduction by prompts:

9. The planographic process is known commercially as offset lithography because the message is transferred ("set off") from the flat surface to a rubber blanketed cylinder; ink then passes from rubber blanket to printed page.

(In the above item, the term 'offset lithography' has already appeared twice in previous items)

29. Typesetting is known as composition. When done by hand, each character of type has been separately cast. In machine composition, however, an entire line of type is cast. Thus the machine is known as a linotype.

IV. Develop the web of learning. This is done by tying the new to the old, the unknown to known, and by providing as many synonyms and antonyms for the concept as possible, often progressing from concrete illustration to abstract definition and back again. Ellis cites this as the Herbartian principle of the apperceptive mass and notes that with large and heterogeneous classes the problem of knowing what is known as common knowledge is difficult. (11, p.147) Thus, the programmer must be certain that the preceding three steps are complete (i.e., that the student is well acquainted with the concept at least in definition form).

Basic to the web of learning is a process and a product. The process is formulation of the answer to questions; and the product is understanding (rather than rote learning). The learner should know why and how he has trod certain pathways so that, if paths are forgotten, they can be reconstructed.

The web is constructed by repetition and by developmental sequence.
Repetition:

1. Pure repetition, or practice of the response. Once the technical term has been introduced, the following frames should require that it be emitted, first alone and then in combination with other technical terms with which it is linked. E.g.:

2. In the letterpress, or raised printing process, ink is transferred from the ___ surface of type (typeface) to a paper surface.

5. Linoleum block printing and rubber stamp printing are examples of the raised (relief), or ___ process.

17. In the platen and cylinder presses, type is locked up in a metal frame (the chase) and printed from directly; on the ___ press, however, a paper mache mold (matrix) is made from the raised type.

18. This paper mache mold, known as the ___ , is then hardened by scorching and filled with molten type metal. The resulting plate is known as a stereotype. (Reminder: although the stereotype plate is cast thin, the typeface is still raised - i.e., in relief).

2. Repetition by variation, or use of many examples. If the grammatical construction is irrelevant to the concept, it must be varied so that it will cancel out. If it is integral to the concept, it must be repeated so that the association is learned. In short, when there are several ways to say the same thing, they should all be used. E.g.:

6. When we cut, or gouge our message into a flat metal surface, then we are using the ___ or ___ process. (Two names for the same process).

Developmental sequences:

1. From known to unknown, in which we move from a common definition of the concept to the experiences which
relate to it (and the technical terms that describe the common concept). E.g.:

11. Intaglio printing is done from a(n) surface, which may be prepared either mechanically (by gouging or scratching) or chemically (by etching with acid).

12. Currency, stocks and bonds, and certificates are usually printed from a mechanically engraved surface. When acid is used to prepare the surface, the process is known as etching.

2. From concrete to abstract. As an illustration, children are taught the value of numbers and the operations performed with them by using such objects as oranges, apples, and pies. As numbers and their operations become meaningful, these objects are withdrawn.

There are no examples in the Boston University study of this type of developmental sequence; all concepts dealt with are concrete.

3. From common experience to a technical description or explanation thereof. E.g.:

5. Linoleum block printing and rubber stamp printing are examples of the raised (relief), or letterpress process.

30. A linotype machine is used for the typesetting, or of practically all commercial letterpress printing. It has the advantage of speed and an even, or justified right hand margin.

31. The typewritten letter does not have a justified right hand margin as a linotype-composed letter does.

V. Introduce prompts to lower the probability of error. This may be done by a number of devices; seven such devices follow:
1. **Similarity**: of ideas, of words, of grammatical construction. E.g.:

3. In the planographic process (lithography), ink is transferred from the planar surface to paper. The printing surface was originally stone (Greek: lithos), but today aluminum or other metal is used.

14. In the rotogravure method, areas that are etched deeper hold more ink than shallower areas and therefore print darker.

2. **Contrast**: of ideas or words. E.g.:

10. The multilith machine is an example of offset lithography: the planar surface (thin metal or paper 'masters') may be typed on with an extra-oily ribbon. Water sponged over the master adheres to the porous untyped areas but is repelled by the oily typing. Ink now applied adheres only to typing.

3. **Grammatical Construction**: used to limit the range of possible responses. E.g.:

20. The difference between the rotary press and the offset press is that the offset press prints from a planar surface, whereas the rotary press prints from a raised surface.

4. **Echoic Devices**: E.g.:

2. In the letterpress, or raised printing process, ink is transferred from the raised surface of type (typeface) to a paper surface.

5. **The Sense of the Whole**: an obvious answer resulting from a consideration of the sense of the whole. E.g.:

16. Returning now to the letterpress process, which prints from a surface, there are three types of presses: platen, cylinder, and rotary.

17. In the platen and cylinder presses, type is locked up in a metal frame (the chase) and printed from directly; on the rotary press, however, a paper mache mold (matrix) is made from the raised type.
6. **Hints:** references to earlier learning. E.g.:

8. Offset lithography utilizes the fact that oil and water do not mix. A curved metal planar surface bearing the printed message in wet, oily printer's ink is flooded with water. Ink from a roller passed over the surface will adhere to the oily printed message and be repelled by the ________.

7. **Mechanical Devices:** concerned with the physical appearance of the item on paper. E.g.: giving the first letter of the answer, indicating the number of letters by dashes, varying color or size of type, placing prompt in proximity with answer blank, etc. The two examples of prompts on Page 66 of this paper utilize the mechanical device of proximity.

**VI. Gradually reduce and finally remove prompts.** An example of this process may be seen in the sequence of items 1, 2, 5, and 16 (occurring on pp. 65, 67, and 69 of this paper).

**VII. Summation.** After all the concepts and their operations are learned, put them all into a problem so that they will constitute a whole and become integrated. E.g.:

21. The difference between the cylinder and the rotary press is that the ________ prints from a curved plate known as the ________ whereas the ________ prints from a bed of type locked in a ________.

* * * *

35. On both the ________ and ________ presses, linotype composition is used to print a high-contrast, error-free master copy - the reproduction proof. This reproduction proof is then photographed to obtain a photo transparency to use in exposing the sensitized plates.

**VIII. Review:** This process is the natural consequence of VI. above. In general, the more the repetition that is required
for learning, the more frequent the reviews which must be given. These should be immediate (every five to ten frames) and delayed (every twenty to forty frames).

The question of what type of material should be programmed remains. Ginther notes that the subject matter should be stable to change, since the automation of a program will probably have lasting effects. He raises the question of whether educators in any field can agree on a limited specific body of information that should be programmed (17).

Ginther distinguishes between stochastic and recursive learning. The former "enables the individual to extract from contingencies between events the expectation that when one event occurs the other will (e.g., statistical probability, trial and error, and rote learning)." The latter area, recursive learning, involves the "construction of plans or methods for figuring out the world." This is the area concerned with the formation of attitudes and values (e.g., philosophy, religion, history). Psychologists who attended the First Conference on the Art and Science of the Automated Teaching of Verbal and Symbolic Skills (Dec. 8, 9, 1958) were in agreement that "stochastic learning can be accomplished efficiently through the machine; there is probably a great deal more of this kind of learning involved in education than we realize." (17) With regard to the area of attitudes and values, Galanter notes that
"if only the machine is used, teaching reflects a narrow outlook on the potential of the mind... there must be other teaching to cover recursive material." (17) As shown in Chapter II, this is the area where studies have shown the personal influence to be all-important. And as shown in Chapter III, in these areas it is most difficult to determine whether or not learning has taken place; we often lack a transfer situation - a specific on-the-job task.

However, the bulk of learning, both in schools and industry, is stochastic. To the extent to which such material can be automated - to this extent we will free the teacher for the no less important task of imparting recursive knowledge. It is sometimes convenient to classify all learning as emotive, cognitive, or directive. The diagram below, although crude, will serve to link these three areas to those already discussed. Further, it should show the reader the overlapping of any arbitrary classification and give a better idea of what types of activities can be programmed.
CHAPTER V

THE HARVARD UNIVERSITY PROGRAM

A Brief Review of the Self-instruction Program
in General Psychology at Harvard University

"Education which is simply intellectual taxidermy -
the scooping out of the mind and the stuffing in of facts -
is worthless. The human mind is not a deep-freeze for
storage but a forge for production; it must be supplied
with fuel, fired, and properly shaped.

William A. Donaghy, S.J.
President, Holy Cross U.
Deep in the basement of Harvard University's Romanesque Sever Hall is a battery of ten machines that have already made their impact in the field of education. For more than 600 students have learned their General Psychology at the hands - or rather handles - of these machines.

The joint advantages of proximity and program extensiveness and thoroughness render Harvard an ideal source of information about the efficacy of a teaching machine program. Their findings concerning the principles of programming, derived from detailed analyses of the answer tapes turned in by students, have already been discussed. We are here interested in the effects of presentation of a well programmed course, after such principles have been applied and pre-tested.

The following review is the result of interviews and participation as another student of psychology carried out by the author during the spring of 1960. It is only with the cooperation of Dr. B.F. Skinner and his Research Associate, Dr. J.G. Holland, that this information was procured; the author herewith acknowledges his debt of gratitude.

* Although several dozen colleges and universities have experimented with automated teaching, the program at Harvard has been in operation longer and has gone deeper into self-analysis than any other program at the present time.
The teaching machine program was prepared and used in General Psychology, which is normally elected to fulfill a requirement in the natural sciences. The students were mainly sophomores, although members of other classes were admitted with special permission.

In the spring of 1958 there were 48 disks, or sets of material; each contained 29 frames, or items. In the spring of 1959, a revised and extended program was employed; this consisted of 60 disks of 29 frames each. Among the topics covered were reflexes, Pavlovian conditioning, operant conditioning, discrimination, motivation, emotion, techniques of personal control, and psychotherapy. In each of these topics, appropriate experiments were analyzed by the students in their work on the machines. In general, the machines taught the basic core of the course, while lectures and outside readings dealt with broader implications.

The machine work was done in a special self-instruction room, which was open all day. Students reported to the room at times of their own choosing, much as they would for a reserve reading at the library. The room contained ten booths which were completely sufficient to handle the enrollment of 187 students in 1958 and 146 students in 1959. Present enrollment is slightly more than 300 students; no analyses have yet been completed for the year 1960.

Disks were checked out from an assistant on duty in
the self-instruction room. The machines use a circular disk consisting of wedge-shaped segments which appear in the window and present one frame, or item of information at a time. Like most teaching machines, the Harvard model requires a write-in answer on the answer tape appearing in a separate window. The student operates a lever which exposes the correct answer and moves his own under a transparent plastic window. If correct, he moves his lever one way to record this (the machine punches a hole in the answer tape); if incorrect, the student moves his handle another way and no score is recorded.

The machine designed by Harvard differs from most commercially available models in that only items answered incorrectly reappear after all items on the disk have been attempted. They will continue to reappear in normal sequence until answered correctly. Although mechanically feasible on a turntable-type machine, this feature is extremely difficult on the friction drive roller machines that require a paper band. The Harvard program, however, is not without its mechanical snares, and students must occasionally seek help from the assistant.

Perhaps the most significant factor in this self-instruction program is the stress placed on revision of disks to minimize ambiguity, misleading order of presentation, and gaps when the program moved too fast. Here, as in no other teaching technique, the teacher has the necessary feedback
to improve the content and presentation of teaching material. A perfectly programmed course will enable all students to answer all items correctly on first encounter. Recurrent errors, then, do not reflect the student's ignorance (we are teaching rather than testing), but rather a weakness of the program at a particular point.

Since the course utilized teaching machines for two successive years, an item by item analysis of the students' answers in 1958 permitted extensive revision for presentation in 1959. As a result, approximately half of the errors made during the first year were eliminated (from 20.1% in 1958 to 11.0% in 1959). Of less significance but equal interest was the diminution of improperly self-scored items; i.e., correctly answered items marked incorrect, and the converse (from 3.6% improperly scored in 1958 to 1.4% in 1959).

A sample of the revised program (Disk No. 9) with an itemized breakdown of the percentages of correct responses is included at the end of this chapter. (See Inclosure A)

Revision of the program also enabled the students to reduce the average time spent on the first time through a disk from 15 minutes in 1958 to 12\frac{1}{2} minutes in 1959. Figure 1 (next page) shows a frequency distribution of the median times in minutes for completion of first cycles (first time through a disk); Figure 2 compares this with the distribution of median times for completion of an entire disk, including time for the repetition of errors.
The 1958 curve shows a greater spread of errors, especially when time for correction of errors is included. The shift in distribution of the 1959 curve between Figures 1 and 2 is slight, reflecting the fact that many fewer errors were made in 1959. The solid line in Figure 2 indicates that the easiest disk was completed in about eight minutes by the median student. The fastest student was able to complete this disk in about three minutes and the slowest required 15. A typical disk required about 13½ minutes for completion, with the range being 5 to 25 minutes. The most difficult disk required 21 minutes for the median student, with a range of 14 to 37 minutes.
A review of the 1958 final examinations provides a crude comparison of the effects of machine teaching with lecture and textbook teaching. All questions were judged to be of approximately comparable difficulty. Nevertheless, the questions for which the machine work was most relevant provided nearly twice the number of correct answers than were provided by questions for which the machine work was not relevant. Furthermore, much of the testing, particularly in 1959, was done with short essay questions. Results indicate that machine-taught students have done well in writing short compositions requiring integration of several different principles.

Since students were free to complete as many disks as they desired in one sitting, it was possible to compare distributed and massed practice. A few students completed all the disks in several long sessions, while others worked in many short sessions doing three to six disks per session. The distributed group never had any sessions longer than six disks, while the massed group contained students whose two shortest sessions totalled more than 27 disks. (One of these subjects completed the entire 48 disks in two sessions. Test results indicated that the way practice was distributed apparently makes little difference. And since one month elapsed between the closing of the self-instruction room and the final examination, the massed practice group cannot be explained away in terms of a short retention.
Each year at the end of the course the students' impressions were solicited by means of a questionnaire. The results are shown on Inclosure B. In general, the impression was somewhat more favorable in 1959 than in 1958, presumably as a result of the revision of the program. The more negative comments were generally made by persons who had done poorly in the course. Despite the fact that many students felt that they were being treated like experimental organisms, only a small percentage felt that the machine reflected on their dignity as human beings. More significant, however, is the fact that about one-third felt that they were missing opportunities to reflect on materials and consider their implications. This criticism could be corrected in the lectures and assigned readings.

In conclusion, both teachers and students have accepted the automated teaching program at Harvard with enthusiasm and the conviction that it is a more effective technique than the classroom presentation that it replaces. Better students are particularly enthusiastic in their praise. Comprehension has proved to be considerably greater. By far the greatest advantage, however, is the possibility of a yearly revision of the program, based on detailed information obtained from the students' behavior. According to Holland, "Progress is assured with this technique of teaching".
CHAPTER VI
THE BOSTON UNIVERSITY EXPERIMENT

A Study of the Automated Teaching Method in Presenting a Course in Graphic Arts

"Lack of evidence on the value of training does not indicate that training is unimportant. Some trainers might even claim that the benefits are too obvious to deserve investigation. Everyone knows that teachers help one to learn music and that a coach assists one in attaining perfection in sports. College professors are credited with teaching students although no one has experimentally demonstrated that they are essential."

Norman R. F. Maier
THE BOSTON UNIVERSITY EXPERIMENT

An experimental study of the relative effects of personal (lecture) vs. impersonal (teaching machine or assigned reading) presentation of learning material was undertaken at Boston University's School of Public Relations and Communications during the Spring of 1960. The experiment involved presentation of a one-week segment of the PR 331 course in Corporate Journalism dealing with the printing processes.

The purpose of this study was fourfold:

1. to determine the relative effects of the means of presentation on the learning process;

2. to determine the 'programmability' of the subject matter;

3. to determine whether the subject matter was transferrable to specific problem situations rather than simple identification tasks; and

4. to develop programming skills in the investigator.

Three experimental groups of 12 students each were exposed to a presentation of matched subject matter.* Each group received instruction by a different means of presentation: classroom lecture, Foringer teaching machine, or reading assignment (See Inclosure C). Students of one group were excluded from admission to either of the other groups. Lecture Group students received a classroom pre-

* equivalent content and approximately equal exposure time.
sentation; students of the Reading Group and Teaching Machine Group received their instruction individually at scheduled hours (in the library and the Communications Research Center office, respectively). Every attempt was made to see that conditions of presentation were as unbiased as possible, including subsequent analysis of the lecture, tape recorded during presentation.

As in all learning experiments, the motivation variable is most difficult to control. Fortunately, in this study individual student preferences for method of exposure divided the class into three almost equal groups. Subjects were thus assigned to the group of their own choice in all but a few instances. A friendly spirit of inter-group competition arose, fostered by the knowledge that they would be tested subsequently and that each group would be trying to outdo the other two groups. Although intrinsic motivation was lacking in that the students had no immediate use for the learning material, students nevertheless expressed a general interest in the experiment and a willingness to cooperate.

Students were informed that they would be tested and graded on their comprehension of the material and that they could take notes to study later. This procedure was followed in order that the lecture group might not be favored by the organizing and reinforcing effect of taking
notes. Presumably, students of all three groups would organize the material into a personally meaningful form during exposure. (It should be noted here that testing came 'by surprise' and that students were not given the opportunity to study. This was done to eliminate the possible 'cramming effect' variable).

Subjects were exposed to the learning material during the third week in March; testing took place during the 1st and 4th week following exposure. The method of exposure was as follows:

**Lecture Group:** Students attended the 50 minute lecture as a group. They were encouraged to ask any questions necessary to clarify the subject matter presented; questions (5) were answered as they were raised. All the material presented to the other two groups and required for the test was covered (as verified by a subsequent check of the tape made on the concealed tape recorder). Influence of this variable was negligible in that the investigator prepared the material for all three groups, based on his experience in teaching the same subject matter to previous classes. Students were observed to be taking comprehensive notes.

**Reading Group:** Students were given a reading assignment on reserve in the S.P.R.C. Library (See Inclosure C). The librarian recorded the name and time for each student
using the reserved book. Books were not permitted out overnight or during the weekend. Upon questioning during the test, students of this group revealed that they had taken notes during the reading (with two exceptions).

Teaching Machine Group: Students arranged with the Secretary of the Communications Research Center for an assigned time on the teaching machine and reported to her at that time. They were briefed on its use (See Inclosure D) and given five practice items to acquaint them with the operation of the machine and the nature of the program. Each student was then left alone to complete the program.

After completion of the 36 items, the student was instructed to add up the errors on his personal Record of Correct Responses (See Inclosure E); if this number exceeded six errors, the student was required to repeat the program. Pretesting of the 36 item program (See Inclosure F) revealed the advisability of permitting this higher error rate (16%); students were new to both the machine and its contents (unrelated to previous course material).

Results of the Record of Correct Responses are shown in Table 1. It should be noted that no student required a third time through the program; three students reached criterion (fewer than six errors) on their first exposure. In the absence of a mechanism that would drop out correctly answered items on subsequent exposures, a perfect (no error)
score was not required. Pretesting revealed the advisability of the six error (maximum) criterion.

After completing the program and turning in the Record of Correct Responses, each student was asked in a casual conversational manner what he thought of the automated program. These comments were later recorded and appear in Table 1.

Table 1

<table>
<thead>
<tr>
<th>Ss</th>
<th>No. Errors 1st Exp</th>
<th>No. Errors 2nd Exp</th>
<th>Time 1st Exp</th>
<th>Time 2nd Exp</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.V.</td>
<td>7</td>
<td>2</td>
<td>60</td>
<td>50</td>
<td>Loves machine; happy with it and self.</td>
</tr>
<tr>
<td>E.U.</td>
<td>12</td>
<td>3</td>
<td>60</td>
<td>30</td>
<td>Good way to learn; got most answers 1st Exp.</td>
</tr>
<tr>
<td>S.W.</td>
<td>7</td>
<td>3</td>
<td>45</td>
<td>25</td>
<td>Not bad; like it.</td>
</tr>
<tr>
<td>Ha.M.</td>
<td>5</td>
<td>*</td>
<td>60</td>
<td>*</td>
<td>Terrific, challenging; Not boring as teacher</td>
</tr>
<tr>
<td>R.D.</td>
<td>4</td>
<td>*</td>
<td>45</td>
<td>*</td>
<td>Effective, learned much in short time</td>
</tr>
<tr>
<td>M.R.</td>
<td>8</td>
<td>6</td>
<td>25</td>
<td>20</td>
<td>Just learning words; Want to see presses.</td>
</tr>
<tr>
<td>H.Mc.</td>
<td>18</td>
<td>3</td>
<td>45</td>
<td>45</td>
<td>Hard to concentrate; Got a lot 2nd Exp.</td>
</tr>
<tr>
<td>J.R.</td>
<td>5</td>
<td>*</td>
<td>45</td>
<td>*</td>
<td>No comment.</td>
</tr>
<tr>
<td>R.R.</td>
<td>7</td>
<td>2</td>
<td>40</td>
<td>20</td>
<td>Learn much better than from book.</td>
</tr>
<tr>
<td>He.M.</td>
<td>13</td>
<td>5</td>
<td>45</td>
<td>30</td>
<td>Frightened - not know what to expect.</td>
</tr>
<tr>
<td>M.S.</td>
<td>11</td>
<td>3</td>
<td>60</td>
<td>20</td>
<td>Good way to learn; Interesting.</td>
</tr>
<tr>
<td>R.S.</td>
<td>11</td>
<td>1</td>
<td>50</td>
<td>15</td>
<td>Helps organize mat., but hard to review.</td>
</tr>
</tbody>
</table>

* 2nd Exposure not required; fewer than six errors on 1st Exposure.
There is no significant correlation* between error rate and time spent on the program. We should note, however, that this is the very reason for machine preference: that slower students can spend more time learning the material than faster ones. Such a correlation would only appear if students possessed equal ability and background preparation. No such attempt to match the three experimental groups was made in this study. However, based on the students' past academic records, it was observed that no group appeared to be skewed in favor of slow or fast students; in short, the distribution appeared to be normal.

**Testing**: Time lapse between exposure and testing varied among subjects, an unfortunate result of the impossibility of scheduling all readings and machine presentations simultaneously. Span ranged from 1-7 days, the mode being 4-5 days.

Subjects of all three groups were tested during the lecture period belonging to Professor A. J. Sullivan, who is responsible for the course. In this way students, who expected to be tested during section meetings, had no chance to prepare other than the exposure presentation. In addition to minimizing the variable effect of 'cramming', this served to facilitate test administration in one session rather than by sections, which would have required matched tests.

* by inspection
The test itself consisted of three parts: identification, application, and description (see Inclosure G). Students who were absent during the exposure week and had not seen the presentation material were also required to take the test and instructed to do their best; these Ss served as a control group. The results are in Table 2.

A second and final test (see Inclosure H) was administered four weeks after exposure to determine the relative effects of varied presentation methods on the rate of forgetting. Again there were three parts. There were 25 points possible on the first test (10,5,10) and 20 points on the second test (10,5,5). The results are in Table 3.

As a test of reliability, correlation coefficients were determined for Ss' scores on the two tests, using the equal forms method. Values of rho revealed that the tests were reliable.

Two measures of validity were used: Both tests were given to two groups of two students each who were not enrolled in the PR 331 course. One group used the automated program to answer the 'open book' tests; the other group used the reserve reading. Similarly, the tests were administered to an industrial editor and a professional printer, this time without presentation of the teaching material. In both cases, inspection of the high performance levels revealed that the tests were valid.
Tables 2 and 3

A Comparison of Scores Obtained by Ss Instructed by Three Differing Methods of Presentation

Table 2 - First Testing (one week after exposure)

<table>
<thead>
<tr>
<th>Exposure Method</th>
<th>Time Ss Exposed</th>
<th>Mean Scores by Areas</th>
<th>Mean Total Score</th>
<th>Stand. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>48 min.</td>
<td>4.4 1.9 5.8</td>
<td>12.1</td>
<td>3.0</td>
</tr>
<tr>
<td>Lecture</td>
<td>50 min.</td>
<td>4.2 1.8 5.6</td>
<td>11.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Teaching Machine</td>
<td>67 min.*</td>
<td>4.6 2.3 5.0</td>
<td>11.9</td>
<td>3.3</td>
</tr>
<tr>
<td>None (control)</td>
<td></td>
<td>2.4 0.8 1.0</td>
<td>4.2</td>
<td>///</td>
</tr>
</tbody>
</table>

* Mean total of all exposures (1st and 2nd) for each S, including machine familiarization time, estimated at 15 minutes.

Table 3 - Second Testing (four weeks after exposure)

<table>
<thead>
<tr>
<th>Exposure Method</th>
<th>Time Ss Exposed</th>
<th>Mean Scores by Areas</th>
<th>Mean Total Score</th>
<th>Stand. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>same as above</td>
<td>4.1 2.9 1.4</td>
<td>8.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Lecture</td>
<td></td>
<td>4.5 2.7 1.5</td>
<td>8.7</td>
<td>2.3</td>
</tr>
<tr>
<td>Teaching Machine</td>
<td></td>
<td>4.9 2.4 .9</td>
<td>8.2</td>
<td>2.8</td>
</tr>
<tr>
<td>None (control)</td>
<td></td>
<td>2.7 1.9 .0</td>
<td>4.6</td>
<td>///</td>
</tr>
</tbody>
</table>
Interpretation and Results: By inspection of Table 3, we may conclude that Subjects of all three methods of presentation showed no significant difference in scores on the second test; a similar inspection of Table 2 reveals a close proximity of the three Mean Total Scores. This indicates that the 'impersonal' presentation by the teaching machine can hold its own with lectures and textbook presentations.

Students taught by the automated program appear to be somewhat weaker in descriptive ability (Tables 2 and 3), resulting from (a) the brevity of items which must fit spacial requirements, and (b) the lack of exemplary items in the program used. Further, as will be shown in our discussion of the error rate (pp. 92,93), the last eight items on the program moved too rapidly. Ss made most of their mistakes in this area, and it was in this area that most of the difficult description took place.

However, in his ability to apply material to practical job situations (transfer of learning), as well as in his ability to identify (recognition), the student of automated instruction is as well prepared as the student instructed by lecture or book.

* This was verified by a test of significance. (Kruskal-Wallis)
Student acceptance of the automated teaching program varied, but was highly favorable in the majority of cases (2/3). (see Table 1)

A comparison of the Mean Total Scores of Tables 2 and 3 reveals that there was no significant difference in retention (rate of forgetting) among Ss of the three groups. As would be expected, scores obtained by Ss of the three experimental groups were nearer the control group score after four weeks of forgetting (Table 3) than after one week (Table 2).

Results of each Ss Record of Correct Responses were entered on a master error record (see Inclosure K). This record indicates the item by item error rate, thus showing which items were ambiguous or not properly prepared for. Analysis of the answer tapes revealed the reasons behind the errors. It was a revelation to this investigator to be able to see so clearly and forcefully exactly where and why the teacher's message had failed. For example, Item 12 (see Inclosure F) was the first big stumbling block (7 errors), though apparently an easy item. The answers ('intaglio'-3, 'chemical'-3) revealed that not enough emphasis had been placed on the desired answer ('etching') when presented along with the wrong answer words. The correct answer word will have to be used several times in the revised program before it is required as an answer.
As another example, Item 28 produced six errors from the 12 Ss, a 50% error rate. Answers ('platen', 'cylinder', 'letterpress') revealed that the Ss were being mislead by the reference to 'raised type', a phrase formerly used to prompt such answers. In revised form, this item should stress the continuous feeding from a roll (web) instead of the raised type. In using the phrase 'raised type', the investigator had tried to point out the difference between rotary and offset, which can also print continuously without reversing direction, but the students had not been taught this fact.

Item 32 was found to read too much like a test question in 'trapping' the student; 'ink' is the immediate answer which comes to mind - only with careful reading will the answer 'water' emerge.

In Item 35, the phrase 'linotype composition' is misleading, suggesting letterpress printing as revealed by the answers ('platen & cylinder', 'rotary & cylinder', 'rotary & platen', etc.).

Item 36 suffered the same problem noted for Item 12 above. The answer had not been prepared for sufficiently in advance.

Items 23-27 were illustrated with diagrams and served as a final review of the preceding material. The higher error rate found on the remainder of the program (Items 27-36) indicated that the program was moving too rapidly in an attempt to cover the remaining material. The programmer had
assumed that Ss would by now be familiar with the nature of the program and would thus require less reinforcement on new items. This assumption is invalid: items must be brief, short-stepped, and frequently reinforced no matter how solid the foundation of previous sequential learning.

That the amount of reinforcement required varies between fast and slow students is forcefully illustrated by the fact that the faster students' error rates remained constant throughout the program, while slower students encountered most of their difficulty on the last eight items. Again, this defends the need for a correct-item drop-out device on machines that present programs for use by fast and slow students alike. In the absence of such a device, the ideal solution would require several different programs for the same material, differing only in the amount of reinforcement present. All students of such a course would start on a slow program; their performance on this and subsequent programs would prescribe whether fast or slow programs should follow.

**Brief Summary and Conclusions:** In the teaching of material involving such tasks as identification, procedures, and simple concept formation, learning seems to take place under conditions of self-instruction at least as well as under present methods of classroom presentation by the teacher. To the extent that the self-instruction material is well programmed, learning under such conditions can be
accomplished faster and with less effort than under conditions of conventional presentation.

There is no apparent loss in 'transferability' of subject matter resulting from the simplification process inherent in programming for self-instruction: students of the teaching machine could apply their knowledge to on-the-job problems as well as students of other groups.

Comparison of the errors made on a student's answer tape with the errors committed on the tests indicated that a revision of the program would yield higher scores and shorter exposure time required for students taught by self-instruction devices. This would indicate a clear superiority of automated teaching in the areas investigated.

The comparison of answer-tape errors with test errors also revealed that errors committed at least twice often become learned by the student. This would indicate that a minimal error rate is desirable, the only tolerable errors reflecting the student's misreading of an item or forgetting of previous items, rather than the non-comprehension of an item. In other terms, when a student has committed an error, he must be able to retrace mentally the steps (items) by which he arrived at the present error and thus discover where in the process he 'short-circuited'. This type of learning is most difficult under lecture conditions, a good bit easier with textbooks, and easiest
with the automated instruction program.

To date, only with the specificity and immediacy of feedback granted to the teacher by the analysis of answer tapes can the gaps and breakdowns in the teaching message be located and corrected. Perhaps a realization of the importance of feedback will make way for other means of presentation by which the teacher can know at any moment where the level of attention, comprehension, and learning stands.
"A basic fact of life for the applied scientist should be kept always in mind: it is not enough that in the experimental situation the proposed new methods work well. They must do so in the average situation where they are to be used and with average people there; and they must there be sufficiently better than the methods and materials these same people have been using, that a change-over is both warranted and feasible."

S. L. Pressey
CONCLUSIONS AND RECOMMENDATIONS

We have attempted to review all relevant evidence at our disposal that might indicate possible uses of automated teaching principles in schools and industry alike. From these considerations, programming for self-instruction would seem to emerge as holding great promise for certain kinds of material and certain purposes. Automated teaching has been credited with:

1. saving time and labor of teachers;
2. providing immediate reinforcement to students, thus increasing motivation and learning;
3. dealing effectively with the range of individual differences present in the classroom;
4. teaching the complex relationships involved in verbal thinking (without apparent loss in the transfer situation);
5. enabling the teacher to improve and standardize the level of attention, comprehension, and learning through program revision;
6. permitting rigid quality and quantity control of the subject matter; and
7. granting continuous testing of the student's progress instead of widely spaced examinations.

The experiments conducted at Boston University (Chapter VI) verify these findings, with two reservations. On the 3rd item above, individual differences will be met only when the machined program can adapt itself to the student using it (for example, by means of the correct answer drop-out device discussed earlier). And on the 7th
item, it was apparent from our studies that mastery of
the automated program does not preclude testing; indeed,
as the nature of the material approaches rote learning,
perfection of the program may have little to do with
recall or transfer on subsequent testing.

It is evident that the teaching machine will never,
nor was it intended to, replace the teacher. Indeed,
such devices require - and cultivate - a superior teacher
in the role of programmer. Perhaps it is here that the
machine will have its greatest effect. As Pressey has
noted:

"One little mentioned advantage of a good self-instructional
device is that it facilitates research. With enough materials
and several sections of a large class available, it may be possible
to gather useful data even in one day, process it the next,
and so very rapidly get some helpful information on a variety
of questions; e.g. desirable difficulty of questions, comparative
value of different forms and arrangements of materials,
and so on. Sometimes the results may be very disillusioning.
The writer found that one of his most promising layouts for self-instruction
actually brought a bit less learning than the same total amount of time spent
by the students simply in ordinary study!" (14, p.196)

Whether or not it becomes the means of presentation
of training material in schools or industry, the teaching
machine's possible use in determining the most effective
presentation methods cannot be denied. It requires at the
outset a definition of objectives of the training and the
establishment of boundaries of relevant knowledge to ac-
complish these objectives. Much of present day training does not get beyond this first step and could certainly benefit from such an exercise.

The above mentioned use of the teaching machine as a research instrument is by no means restricted to schools and industry. It is conceivable that as knowledge of effective programming procedure becomes widely practiced, specialists in communications will be able to pretest a message on a limited sample public by programming it. We have learned from the schools that over-conscientious teachers often waste time and lose interest in teaching students what they already know and trying to prevent errors that are unlikely in the first place. In so doing they sometimes cause student errors that would not otherwise have been made. In such fields as advertising and public relations, where time and space for public attention is at a premium and where each word printed or spoken is measured in dollars as well as in sense, it is well within reason for us to turn to whatever research methods may be applied to the formation of a more effective message and the increased control and predictability of its reception. (See examples in Inclosure N).

In Chapter III we discussed such concepts as attention, perception, motivation, reinforcement, and transfer as they relate to the learning process. These same concepts are discussed at length in books dealing with psychology
in advertising and psychology in industry. If these concepts can be systematically controlled by programming for machine or other well-designed presentation, the possibilities of increasing the predictability of results appear to be very real. If we ever hope to approach the goal of ultimate control over the communications process, it is even more important to undertake research which will determine how far each of these psychological variables, or combinations of them, can be pushed - and with what effects. This area of research remains relatively unexplored; the teaching machine appears to be an effective tool in controlling such variables.

The problem of what type of material can be programmed remains largely unsolved. We have seen that simple motor skills, facts, procedures, associative learning, simple concept formation, and in general, the majority of those disciplines that Ginther (17) has defined as 'stochastic' can be programmed for effective self-instruction. Beyond this we know little. The limitation lies not with the machine, but rather with the inability of educators to define the nature of the process of instilling values, attitudes, and the complexity of interrelationships that characterize such 'recursive' disciplines as philosophy and religion, for example. A second limitation results from their sacred regard for such areas of study and their conviction that automated teaching can no more convey ulti-
mate values than can the physiology of man, their prototype model.

Such arguments fall down in their failure to recognize the impossibility of divorcing 'stochastic' and 'recursive' material. How can we instill values and attitudes without presenting the facts which help to form them, or at least the preceding values and attitudes out of which new ones grow? Conversely, we are often at a loss in teaching the 'simplest' forms of definition and identification learning when divorced from the larger concepts of which these are a part. How, for example, can we teach the definition of a word like feudalism (presumably a stochastic exercise) without considering the social implications contingent upon its practice (a recursive exercise)?

It is here that the behavioristic approach to automated teaching is inadequate. The atomistic and organismic explanation of the learning process has begged to avoid such issues as whether or not values and attitudes can be taught by machine. They have done this by defining the machine as a teaching aid, which thus relieves and enables the teacher to deal with such elusive material. But the all-important question remains: how is such material taught? E. L. Thorndike has noted:

"The word education refers especially to those elements of science and art which are concerned with changes in man himself. Wisdom and economy
in improving man's wants and making him better able to satisfy them depend on knowledge. The basis of intellect and character is this ... original arrangement of the neurones in the brain."

(41)

But is learning solely a function of these 'original arrangements of neurones'? What of environmental predispositions? What of motivation? It is in these very areas that the answers to our problem of imparting values and attitudes lies.

It seems incumbent, then, on those who will apply the principles of automated self-instruction to the increased understanding and improvement of the communications process to deal with more than the mechanics of change. To the extent to which we use models as analogies and machines as means may we seek an understanding of those areas not explained by these partial devices. And may we never sacrifice man's inalienable right to render his own value judgments by so programming and structuring his receptive experience that there is no room for question. For when man finds ultimate delight in the pragmatic infallibility of a perfectly constructed program, then we have arrived at a problem far greater than any teacher shortage or classroom differential...we will then be dealing, not with teaching machines, but with human machines.
BIBLIOGRAPHY


Items | Correct answers and percentage of students giving the answer | Other answers given by students
---|---|---
15. If an animal's response is not followed by reinforcement, in the future similar responses will occur ________ frequently.

**II. The following are 50 items inter-**

61. A child has a "temper tantrum" screaming for candy. The mother gives the child candy, and the tantrum ceases. The mother's response of handing the candy to the child is ________ by the termination of the tantrum.

62. If termination of a "temper tantrum" reinforces a mother's response of handing candy to her child, the cessation of noise is an example of ________ reinforcement.

63. In the terms of the influence of the temper tantrum on the mother's behavior, the tantrum is a negative (1) ________ and a ________ (2) ________ consequence.

64. When a "temper tantrum" results in the receipt of candy, the probability that the child will have a tantrum in the future ________.

65. The receipt of candy as a result of "throwing" a "temper tantrum" is an example of ________ reinforcement.

66. When the mother placates the child with candy and the child ceases to scream, both mother and child are unknowingly each other's behavior. **Conditioning** (reinforcing) ________.

67. To avoid conditioning "temper tantrums" the mother should not ________ such behavior when it is emitted.

68. If "temper tantrums" have been previously conditioned, the mother can (1) ________ the response by consistently not (2) ________ it.
1. If machines had not been used this year I believe:

<table>
<thead>
<tr>
<th></th>
<th>1958</th>
<th>1959</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>76.1%</td>
<td>84.3%</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>12.1%</td>
</tr>
<tr>
<td></td>
<td>3.2%</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

I would have gotten less out of the course
It would have made no difference
I would have gotten more out of the course

2. In comparing work on the machine with studying the text, I felt that, with the same amount of time and effort,

<table>
<thead>
<tr>
<th></th>
<th>1958</th>
<th>1959</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31.7%</td>
<td>45.3%</td>
</tr>
<tr>
<td></td>
<td>45.3%</td>
<td>33.0%</td>
</tr>
<tr>
<td></td>
<td>7.5%</td>
<td>0.9%</td>
</tr>
<tr>
<td></td>
<td>12.4%</td>
<td>16.9%</td>
</tr>
<tr>
<td></td>
<td>3.1%</td>
<td>3.8%</td>
</tr>
</tbody>
</table>

I learned much more on the machine
I learned somewhat more on the machine
There was no difference
I learned somewhat more from the text
I learned much more from the text

3. If I were to take another introductory course in a science or similar field I would:

<table>
<thead>
<tr>
<th></th>
<th>1958</th>
<th>1959</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>66.7%</td>
<td>76.6%</td>
</tr>
<tr>
<td></td>
<td>16.4%</td>
<td>13.5%</td>
</tr>
<tr>
<td></td>
<td>17.0%</td>
<td>9.9%</td>
</tr>
</tbody>
</table>

Prefer to have machines used for part of the course
Prefer not to have machines used
Do not care whether machines were used or not

4. At some time during the course I felt that, in being taught by machines,

<table>
<thead>
<tr>
<th></th>
<th>1958</th>
<th>1959</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16.1%</td>
<td>22.3%</td>
</tr>
<tr>
<td></td>
<td>5.6%</td>
<td>2.7%</td>
</tr>
<tr>
<td></td>
<td>47.8%</td>
<td>62.5%</td>
</tr>
<tr>
<td></td>
<td>39.8%</td>
<td>30.4%</td>
</tr>
</tbody>
</table>

I was being treated like an experimental organism
The use of machines reflected upon my dignity as a human being
The instructor was trying to teach me as much as possible with a given expenditure of my time and effort
I was missing many opportunities to reflect on material and consider its implications

(Responses to item 4 total more than 100% because some students marked more than one answer)
Corporate Journalism
(Graphic Arts)

Reading Assignment, on Printing Processes:

In Karch, Randolph, Graphic Arts Procedures
(on reserve in SPRC Library and available at bookstore)

pp. 1-6 (describing three major processes); 123 (explaining hand composition and linotype composition); 225, 226 (preparation of stereotypes from linotype composition for use on rotary presses); 246-250 (explains intaglio printing and rotogravure, its commercial application); 231-240 (offset lithography explained).

You will find the charts or pictures on pp. 6, 240, 249, 253 especially helpful.
INSTRUCTIONS
(mounted on panel above teaching machine)

This is a teaching machine, not a testing machine. You will learn new material in each item. Work slowly, concentrating on the new material rather than on simply writing down the answer(s). You will be asked questions in later items about information presented in earlier items.

You may take notes, just as you would in lecture. You will be tested subsequently on your comprehension.

For each item:

1. Write your answer(s) in the window at right
2. Pull the lever at left upward
3. Compare your answer with the correct one beside it. If yours is correct, make a circular mark through the hole above the window; if incorrect, make no mark.
4. Enter a mark in the appropriate column on the Record of Correct Responses beside the machine.
5. Read, study, and answer the next item.

If the machine jams, or you run out of answer paper in the window, ask Mrs. Banks to help you. Do not force the handle.
# Record of Correct Responses

| ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
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**Total Incorrect** □
Printing can be accomplished from three types of surfaces: raised (relief), flat, and engraved. Letterpress printing refers to the raised process, planographic or lithographic refers to the flat process, and intaglio refers to the engraved process.

1. In the letterpress, or raised printing process, ink is transferred from the surface of type (typeface) to a paper surface.

2. In the planographic process (lithography), ink is transferred from the surface to paper. The printing surface was originally stone (Greek: lithos), but today aluminum or other metal is used.

3. The intaglio process transfers ink from the surface of a metal plate to an absorbent paper. Excess ink must be wiped from the surface (with a rubber blade squeegee) so that only the ink in the indentations will print.

4. Linoleum block printing and rubber stamp printing are examples of the raised (relief), or letterpress process.

5. When we cut, or gouge our message into a flat metal surface, then we are using the intaglio or engraving (any order) process. (Two names for same process)

6. When we print from a curved metal planar (even) surface, we are using the planographic (lithographic) process, commercially known as offset.

7. Offset lithography utilizes the fact that oil and water do not mix. A curved metal planar surface bearing the printed message in wet, oily printer's ink is flooded with water. Ink from a roller passed over the surface will adhere to the oily printed message and be repelled by the water.

8. The planographic process is known commercially as offset lithography because the message is transferred ("set off") from the flat surface to a rubber blanket cylinder; ink then passes from rubber blanket to printed page.

9. The multilith machine is an example of offset lithography: the planar surface (thin metal or paper masters) may be typed on with an extra-oily ribbon. Water sponged over the master adheres to the porous untyped areas but is repelled by the oily typing. Ink now applied adheres only to typing.

The following five items are examples and will acquaint you with the operation of the teaching machine and the way in which items of information are constructed. Please write answers to each of these items on the paper appearing in the window at right. Do not enter marks on the record of Correct Responses until numbered items appear. Pull lever.

Red, yellow, and blue are primary colors. They may be mixed to form secondary colors. When red and yellow are mixed, orange is the result. Orange is a secondary color.

Two a. primary colors are required to make a b. secondary color. For example, red and blue are mixed to make purple.

Yellow and blue are primary colors; when mixed they form green.

Green and orange are secondary colors. They may not be mixed to form either primary or secondary colors.

Red and a. blue b. secondary color are mixed to form purple (violet).

Now you should be ready to begin the lesson. If you are still uncertain how to operate the machine or study the items, please consult Mrs. Banks before going further. If you are ready, pull the handle and begin. Mark each response on the Record of Correct Responses.

Inclosure F (5 pages)
22. Each of the three presses can best be remembered by the way in which paper is fed. The platen press receives paper on the platen (flat metal impression plate), the a. press receives paper on the impression cylinder, and the b. press receives it from a rotating, or revolving roll (web).

23. The diagram at right is an example of a(n) ______ press.

24. The diagram at right is an example of a(n) ______ press.

25. The diagram at right is an example of a(n) ______ press.

26. The diagram at right is an example of a(n) ______ press.

27. The diagram at right is an example of a(n) ______ press.

28. The advantage of the ______ press is that it can print from raised type continuously, without reversing direction every time an impression is made. It is thus ideal for the big city newspapers.

29. Typesetting is known as composition. When done by hand, each character of type has been separately cast. In machine composition, however, an entire line of type is cast. Thus the machine is known as a ______.

30. A linotype machine is used for the typesetting, or ______ of practically all commercial letterpress printing. It has the advantage of speed and an even, or justified, right hand margin.

31. The typewritten letter does not have a ______ right hand margin as a linotype-composed letter does.
1. Intaglio printing is done from a(n) _______ surface, which is prepared either mechanically (by pouring or scratching) or by chemical etching.

2. Like rotogravure, offset lithography requires a photographic transparency of the copy, artwork, etc. (layout). Offset lithography differs, however, in that unexposed portions of the sensitized surface are washed away, leaving the absorbent surface to attract _____, which the exposed portions will not do.

3. Linotype composition is printed from directly only on the _______ and _______ presses.

4. On the rotary press, however, linotype composition is converted into a mold, known as the a. _______. Molten type metal is then poured into this mold, cooled, and curved to form the b. _______.

5. On both the _______ and _______ presses, linotype composition is used to print a high-contrast, error-free master copy—the reproduction proof. This reproduction proof is then photographed to obtain a photo-transparency to use in exposing the sensitized plates.

6. The flawless master copy that is photographed and then adapted for reproduction in both the rotogravure and the offset processes is known as a _______ _______.

x. Now write your name again and the time.

y. Now look at your Record of Correct Responses below. Add up the number of incorrect answers. If this sum is greater than six (6), ask the attendant to reset the machine and repeat the lesson, concentrating on those questions missed. If the number is six (6) or less, turn in your Record of Correct Responses ... you are now free to leave.
Corporate Journalism
(Graphic Arts)

Progress Test

Part I (10 points) On what press(es) would you expect to find the following:

- a rubber blanket
- a web of paper
- a chase and
- a scraper blade
- a grained aluminum plate
- a stereotype
- a sponge-applicator
- an engraved metal roller
- linotype composition
  
The Boston Globe (daily)

Part II (5 points)

As editor of your company newspaper (600 copies), you have followed a policy of printing numerous photos of employees - on the job, in recognition of achievement, and in social activities. You print a minimum of copy. Naturally, you find the ________ process most economical and practical.

Your plant is having a company picnic; you want to send out a post card announcement to every employee's family (about 800 cards). The boss doesn't want them mimeographed or dittoed. Thus, you will ask a printer to do them by the ________ process; he will probably do them on a ________ press.

As an industrial editor, you have been called upon by your boss to prepare an institutional ad to appear in four color in the Sunday Supplement section of the New York Times. You will plan on designing the ad for reproduction by the ________ process.

A justified margin, difficult on the typewriter, is accomplished for textbook, magazine, and newspaper composition on the ________ machine.
Part III (10 points)

Describe the printing surface on an offset press with reference to the two materials deposited on it, and explain how the message is prepared and transferred from the planar metal surface to the paper. (5 points)

What is the main advantage of a rotary press over the other presses that do letterpress printing? The main disadvantage? (5 points)
The Printing Processes: Progress Test

Directions: Enter the appropriate number or letter in each blank. (Note whether the name of a method or a press is called for.)

**METHODS**

1. Letterpress
2. Offset Lithography
3. Intaglio (Engraving)

**PRESSES**

(a) platen; (b) cylinder; (c) rotary;
(d) offset; (e) multilith;
(f) rotogravure

Part I (10 points)

Most large city newspapers are printed on _presses_. Four-color Sunday Comics Sections are printed on _presses_. Industrial employee newspapers that are filled with photographs are best printed on _presses_. Office form letters, newsletters, etc. are usually reproduced within an office on the _press_. Short run (say 100 copies) jobs using linotype composition are generally hand fed and printed on _presses_. A curved stereotype is used on the _press_. Composition of purely typographic material is quickest by the _method_. Only in the _method_ would you find a water bottle or reservoir mounted on the press. The press is the only press that does not utilize a flat bed chase for raised printing. The printing surface must be scraped of excess ink on the _press._

Part II (5 points)

Sharp lines to be printed on thin paper would be _least_ likely to be felt on the reverse side of the paper if printed by the _method_. If you needed several billion four-color labels for your product, you would not want the plates to wear out and would therefore print them by the _method_. If you were reprinting a one-color booklet that you produced several years ago and had only a few copies left, you would want it printed by the _method_. If you were planning a national advertising campaign and wanted to mail your ads in the form of matrices (mats), you would be counting on their reproduction by the _method_. If you were editor of a small (500 copy) company 4-page monthly newspaper with few pictures, you would probably have it printed on the _press._

Part III (5 points)

Explain why a transparency (negative photo) of the reproduction proof is needed to prepare the printing surface in both the offset and the rotogravure methods. Include a description of how the surfaces differ.
Three circuits are in operation – a motor circuit, a circuit-breaker circuit, and a paper punch circuit.

The first two are interdependent; the third is independent.

Motor (a) is normally running if source (b) is plugged in and main switch (c) is closed. Switch (d) is a push-button and is closed unless pushed. Friction drive roller (e) moves paper program band (f) until metal brush contact (g) strikes first hole in paper, opposite first item. Brush (g) makes contact through hole with copper plate (h), thus completing circuit with solenoid circuit breaker (j). Breaker pulls motor circuit switch (k) open, stopping motor. After answering item presented opposite hole at (g), student opens switch (d), a push-button, and spring on solenoid circuit breaker (j) closes motor circuit switch (k). This starts motor and moves program to next item (hole), where process is repeated.

Student records answers on answer tape (m). When incorrect, student closes push-button switch (n), thus operating paper punch (o), which punches hole in tape (m) on right hand side. Note that hole is punched opposite item wrongly answered (last item) on program band (f) rather than opposite present item (which gives answer to last item).

After program band (f) is completed once, it begins second time around for corrections. Answer tape (m) is now fed upside-down, with written answers from first time facing down, and punched holes on left hand side, where they fall under brush (p). (Student is thus writing answers on the back of his 'first try' answer tape.) By opening push-button switch (d), student now permits motor (a) to drive program band (f) until an incorrectly answered item appears, at which time brush (p) makes contact through student-punched hole with copper plate (h). Student releases push-button switch (d) after making answer, and the next item to appear brings him the correct answer. By holding push-button switch (d) in, only incorrectly answered items will appear.

Roller (r) may be adjusted up and down to maintain tension in paper band (f) over drive roller (e), and to permit bands (programs) of different lengths to be used.
Master Error Record

A composite record of the entries made by Ss of the Teaching Machine Group in their individual Record of Correct Responses (Inclosure E).

<table>
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Tireless

We intend to keep on informing our readers of the latest developments in the field of automation until the crevpy technological point is reached at which a machine is devised to inform our readers of the latest developments in the field of automation and our poor old brains and beat-up Remington are put on the shelf. On the agenda today is a prodigious toy called Tutor, which its makers, the Western Design Division of U. S. Industries, Inc., define as an electromechanical teaching device, and which presents material to a student, encourages him in his desire to master the material, tests him on what he has learned, congratulates him if his answers are right, detects and corrects any wrong answers he may give, compiles an account of his method of reasoning, and notes improvements, if any, in this method. Tutor is not only brainy but agreeably small, resembling in size and shape a cigarette vending machine. On its face are an eight-by-eleven-inch viewing screen and a panel of forty numbered push buttons; on tap within are up to ten thousand separate microfilmed or motion-picture images. According to Norman A. Crowder, manager of Western Design's Training Systems Department and a co-holder of the Tutor patent, the trim little con-

traption was devised as the result of an inspiration that came to him when, as a research psychologist in the Air Force's Air Research and Development Command, he drew up tests to measure the proficiency of personnel who had been trained to work with intricate electronic equipment.

"I soon found there was precious little proficiency to be measured," Mr. Crowder told us when we stopped in to visit Tutor and Crowder at the U.S.I. offices, on Park Avenue. "Students were being trained by teachers who used the conventional lecture system, which is thoroughly inadequate when it comes to communicating complex material on a large scale. I realized that the success of a learning process could be insured by the invention of a machine that would present information to the individual student and allow him to proceed at his own rate of speed and comprehension."

What, we asked, of the merely human teachers of this world? Were they to be utterly routed by armies of softly humming Tutors? "Not at all," said Crowder. "Tutor presents material step by step, and is intended to teach people how to use equipment or sort the sort of technical problem about which sequentially dependent questions can be asked. History, literature, and the humanities don't lend themselves readily to the automated process. In any event, we're interested not in replacing teachers already in the classroom but in filling the need for more teachers. Learning is an individual matter, and ideally every student should have his own teacher; Tutor will help to realize this ideal. The teaching theory back of Tutor calls for constant two-way communication between the student and the machine. Having picked a subject you wish to study, you sit down in front of the machine and push buttons that, in accordance with a prearranged code, will project the images of a given teaching sequence onto the screen. Each image contains a basic item of information about the subject and a multiple-choice question to test your response to what you have just seen and read. You register your answer to the question by entering the image number corresponding to your choice on the push-button panel. If your answer is correct, the next image will bear a printed message of congratulation, another item of information, and another test. If your answer is wrong, the new image will contain material designed to correct the error in your reasoning and will send you back for a second try at the original question. Meanwhile, Tutor records your progress by listing on tape the sequence of the images you view and the amount of time you spend on each image."

Though Tutor will never supplant the human teacher, it has certain basic psychological advantages over him, or her. For one thing, Crowder pointed out, the student need never feel ashamed in its presence. "People hate to seem inferior," he said. "Many a student hesitates to stand up in class and hazard an answer or answers that may make the book look foolish. The Tutorstudent relishes his confidentiality and encouraging. Tutor strengthens a student's reasoning powers by the exercise of infinite tact and patience. It never grows tired or annoyed, never makes fun of anyone or hurries anyone along for the sake of the rest of the group. It is infinitely knowledgeable but also infinitely kind."
AUTOMATION: GADGET TEACHES STUDENTS

By WILLIAM A. SMITH

CHICAGO (UPI) - One hundred student enrollees have lined up with a handful of hard-working professors to make many work - through automation.

They are attacking one of education's greater headaches.

A classroom instruction geared too fast for the slow learner, too slow for the bright pupil and not ideal, except accidentally, for anyone.

PROJECTS MATERIAL...TESTS THE STUDENT

Their weapon is aChild of automation, a microfilm, a projector and a screen. It is designed for individual students, according to the student's own initiative and ability to grasp a carefully-programmed body of material.

Theoretically the device, which is shown to 10,000 frames of 35 mm film enabling up to 150 hours' study time, will not only project study material but also test the student. In many cases it will produce explanations when his answers are wrong.

Robert Nicolson is a Loyola University psychology professor and work-co-ordinator of next fall at Loyola. He said a major challenge is not the service side, but public, academic misapprehensions about its use.

Monday and Loyola's student-staffed Laboratory of Behavioral Research director, said the device will help much toward easing the nation's present and future shortage of trained teachers.

The device is called an AutoTutor, if requires the student to take an active part in the learning process, it only to the extent of pushing buttons and watching an 11 by 15-inch screen instead of looking out the window.

But, like chalk and textbooks, is basically only an educational tool.

"The AutoTutor is not a replacement for teachers," Nicolson said. "Rather it will supplement the teacher and allow him more time to work with the individual. We hope it will free him from much of the traditional type of classroom teaching."

The AutoTutor is manufactured by U.S. Industries of Western Design Division, Goleta, Calif. It could end up producing more work for teachers and students alike, Nicolson said.

For students instruction based on individual abilities can "take away much of the unhealtful competitiveness," Nicolson said. "Every student can reach a certain level of knowledge."

The Boston Globe, 4 May 1960
It was outlined on pp. 98,99 that the teaching machine might find widespread acceptance outside the classroom. A few such applications are outlined below.

Let us suppose, for example that the industrial editor, training section, or public relations department is required to prepare an instruction manual for new employees. After the copy is written, it could be transferred to a program format and presented to a sample of the intended audience. By using a machine which combines the feed rate control of a speed reading machine with the feedback mechanism of the teaching machine, the author(s) could obtain immediate knowledge as to which sections of the manual achieve their objectives and which sections require revision. Further, the probe questions inserted into the program as stimuli for the feedback responses would indicate why these sections had failed.

Similarly, the advertiser is concerned with acceptance of his message. If the message is presented via machine and reaction to it is solicited on a continuous basis, copywriters can revise their efforts to achieve a more widespread public acceptance. This continuous audience reaction could be accomplished by using a printed answer tape with five columns representing a five point attitude scale. Ss would
move a mounted pencil or pen to the left or right, as done on a kymograph, to indicate their immediate attitudes. Such use of the machine is analogous to the studies made by Lazarsfeld on audience acceptance of TV program presentations, in which sample audience members pressed red and green buttons throughout the show to indicate their attitude(s) at the moment.

In the area of industrial training, the author is presently negotiating with Raytheon Co., New England's largest employer and supplier of electronic equipment, in the interest of installing a pilot study of automated programs that would present the more routine sections of their training program. Such an installation would afford personnel the opportunity of training when their own work schedule best permitted, reviewing the material subsequently as becomes necessary, and giving management the frank responses that the anonymity of the answer tape feedback grants. This enables management to revise the program for smoother presentation, and, far more important, to see with great accuracy the prevalent employee attitudes toward company policy and procedures.

Finally, as a pure research tool, the teaching machine affords us the advantage of control over the psychological variables discussed in Chapter III. This should be valuable, for example, in studying the comparative effects of color vs. black and white presentation. Similarly, in studying the
advantages of varying formats of message presentation, such as the illustrated comic format vs. a strictly verbal message, the machine would offer rigid control of the conditions of presentation. Studies in this area are anticipated in the near future in research being conducted by the Communication Research Center for the National Comics Council.
Boston University
School of Public Relations and Communications
Thesis Abstract

TEACHING MACHINES: A MEANS OF RE-EVALUATING AND IMPLEMENTING TRAINING PROCEDURES

by
Scott B. Parry
(A.B., Princeton University, '54)

Submitted in partial fulfillment of the requirements for the degree of Master of Science
May 1960
INTRODUCTION

In Chapter I the author outlines the problem of an increased demand by industry and education alike for more efficient tools of instruction. The teaching machine is introduced as a new device among visual aids, unique in its ability to grant the student immediate knowledge of his progress. Arguments for and against the device are discussed, with the conclusion that self-instruction devices hold potentials for use in many areas of application. The purpose of the thesis is to examine these potentials by surveying the literature, applying the principles of educational psychology, studying the progress in programming to date, examining the Harvard University program, and carrying out an experimental study at Boston University.

SURVEY OF THE LITERATURE

Chapter II examines the work of Porter in classifying teaching devices of every description, including punchboards, chemical paper, programmed textbooks, "scrambled books", the multiple choice devices of Pressey, and the Skinner machines (prototypes for present commercial models). Advantages and limitations are discussed. Emphasis is placed on the theory of self-instruction rather than the devices per se. The association theory of the behaviorists is cited as an inadequate explanation of the learning process and a limiting
factor in the progress of automated teaching.

APPLICATION OF THE PRINCIPLES OF EDUCATIONAL PSYCHOLOGY

Chapter III applies the basic concepts of educational psychology to the theory of automated learning. Concepts discussed are: feedback, reinforcement, motivation, transfer, association, attention and perception. The teaching machine is shown as providing at least equal or superior conditions for the control and maximum utilization of these variables in the learning process.

PRINCIPLES OF PROGRAMMING

In Chapter IV programming is recognized as the most difficult aspect of automated teaching and probably its greatest deterrent. Common problems of programming are discussed and principles of effective programming are presented, illustrated with items from the program used in the Boston University experiments.

THE HARVARD UNIVERSITY PROGRAM

Chapter V examines the administration and results of the self-instruction course in General Psychology now in its third year at Harvard. Revision of the program based on the feedback from students' answer tapes has made comparisons of its effectiveness possible. Results show that both students and teachers prefer the teaching machine to classroom presenta-
tion. Program revision caused the error rate to be halved (20.1% in 1958 to 11.0% in 1959). On final examinations, students of the revised automated program did as well as former students taught by lecture, although they had spent less time preparing via teaching machine instruction.

THE BOSTON UNIVERSITY EXPERIMENT

(Chapter VI) Three groups of 12 subjects each were exposed to a one-week segment of the PR 331 course dealing with the graphic arts, the method of presentation being varied with each group: lecture, reading assignment, or teaching machine. Length of presentation (exposure time) and difficulty of material were held constant. Two tests followed the presentations, at a one-week and a four-week interval. Results indicate that learning under conditions of self-instruction takes place at least as well as under present methods of classroom presentation by the teacher. With a revision of the program used in self-instruction, one would predict faster learning with less effort than under conventional presentation conditions. Answer tapes revealed where the automated program was ambiguous and where it moved too fast, making revision relatively easy and certain.

CONCLUSIONS AND RECOMMENDATIONS

Chapter VII summarises the advantages of self-instruction methods and enlarges upon their possible use in areas outside
the field of education, such as personnel testing, industrial training in facts and skills, research into message structure and effect in the mass media, control of the psychological variables (Chapter III) at work in the communication process, etc. Potential application of the teaching machine and its modifications seems limited not by the mechanism itself but by the inability of educators and communicators to define their objectives and methods in step-wise relationships that permit microcosmic examination.

A BIBLIOGRAPHY and Inclosures follow.