The Evolution And Revolution Of The Teaching Machine

Part I

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Because of the growing complexity of American business and industry, the pressures upon the training director are increasing at an incredible rate. Years ago, the training member of the personnel team had to be a good instructor, a fair conference leader and informed about principles of supervision. Today, the training director, in some companies, is actually four people: the employee trainer, the management developer, the professional developer and the customer trainer.[1] In other companies, the training director is one person performing, or trying to perform, all four tasks. Many companies are organizationally somewhere in the gray area between these extremes. So complex has the training directorship become, that at least one group is developing a special graduate curriculum leading to the M.S. degree in Training Administration.[2] This would signify the need for professionalization of this career field as a consequence of the broadening and deepening character of its preparational requirements.

Since the end of World War II, a great emphasis has been placed upon methods for developing managers. This has been accompanied by a plethora of techniques most of which are understood and are in general practice but a few of

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which consist purely of witchcraft!! Just as soon as the training director learns and understands a newly introduced method, he is sent reeling by a variant or a completely different and quite revolutionary procedure. How long this will continue is hard to judge but with a greater role being played by the behaviorial sciences in the training field, it would appear that training directors will have more rapid access to experimental data which will suggest new and different methods for dealing with behavior. And it is the *shaping* of *behavior,* which, in the final analysis, is the fundamental function of the training director.

Very recently, a number of periodicals such as *Business Week, Saturday Evening Post, Fortune* and *Time,* among others, have focused attention on the field of teaching machine technology. This field of behaviorial science was making dramatic progress in the period of 1959-60 but was admittedly still in the research and development stage when it reached the public view.

It would indeed be strange for a Training Director to learn about an important new development, such as teaching machine technology, in Fortune Magazine first rather than in his technical or professional journals or at his professional meetings. Therefore, it is appropriate at this time to present an expositional paper to members of ASTD so they will have a firm grasp of the evolution and revolution of teaching machine technology. It has been said, "what is past is prologue," and from this delineation may come the future role of the auto-instructional device in training.

Relation of the Teaching Machine to Training Devices

The device commonly called the "teaching machine" is not new. A long list of patents involving auto-instructional devices indicates early endeavors

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to improve learning by automating the method. A very early effort in this country was patent No. 52758, awarded to Halcyon Skinner in 1866[3]; A search of the records would probably reveal others invented more than one-hundred years ago!

Of all of those involved in shaping behavior by processes of education and training, the Training Director is perhaps the most conscious of the growing movement away from purely *instructor-centered* courses towards the *learner-centered* program which requires active participation by the employee.

This "learning by doing" philosophy was an essential ingredient of the four-step method of job instruction, itself a forerunner of the J.I.T. (Job Instructor Training) effort of World War II's Training-Within-Industry days. It will be recalled that the participation was carefully planned, supervised by the instructor, designed to correct the learner if an error was made, and the learner-instructor ratio was 1 : 1. In J.I.T., the emphasis was on the learner and the technique was an early form of a *learner-centered* method in contrast with the more common *instructor-centered* method as typified by the lecture, lecture-demonstration, or demonstration. It is fair to state, however, that J.I.T. worked best in shop or laboratory environments while the other methods were really classroom-oriented.

"Visual aids" Reach Maturity—Some can still recall training's formative years when the lantern slide projector, 16 mm silent film, slate blackboard and chart were the mainstay of the instructor. These were *instructor aids;* the instructor prepared a lesson plan, or a reasonable facsimile thereof, and then *integrated* available and suitable aids into his lesson. The period of 1941-46 marked the beginning of a new period in understanding the role of visual aids. By June 1945, 457 sound motion pictures and 432 silent film strips were produced by the U. S. Office of Education alone; all of these were specifically designed for training purposes rather than for education. While the addition of sound to the silent film resulted in the "visual aid" becoming the "audio-visual aid," the film remained as an *instructor-centered* device,[4] along with the silent and sound-filmstrip.

The magnetic wire recorder saw little use during the war in training programs partly because it was of non-professional quality and also because training specialists did not devote much time to thinking about its applications. Magnetic tape recording was a German export to this country as a consequence of the Armed Forces Occupation in 1945.[5] One can conclude therefore, that up to 1945, the audio aspect of "audio-visual aids" was fairly well limited to sound-on-film and disc recordings for filmstrip accompaniment.

Beginning in 1942, along with the introduction of radar, a fantastic variety of electronic, electrical, mechanical, acoustical and optical *systems* were delivered to the armed forces. The armed forces consisted, in the main, of civilians who were largely unprepared for technical or military pursuits. The task was to provide the capability to operate and maintain a war machine in which the equipment was untested, the men untrained and the pressures unrelenting! The technical training problem was simply overwhelming. Service schools expanded rapidly and were equipped with every known audio-visual aid.

It was soon found that the traditional techniques in *education* were unsatisfactory in *training* since the criterion for success was *job performance* and this meant formalized "learning-by-doing." Added to this was the *shortage* of equipment and industry's inability to satisfy the insatiable requirements of war.

As the training pressures increased, the potential abilities of trainees decreased and the numbers of trainees grew. Facing this together with absences of equipment, trainers in the armed forces devised ingenious substitutes and invented new and better methods. The traditional "audio-visual aids" were expanded to include three-dimensional still and motion picture projection, flip and roller charts, flannel board presentations, demonstration boards, audio devices, and an infinite variety of models: full sized, operating, scaled and mock-up. Since classroom instruction was totally inadequate, trainers tended to emphasize shop, laboratory or environmental training which *simulated* the actual situation as faithfully as conditions would permit. In this arrangement, the classroom was supplemental to the shop or laboratory phase.

The pressures continued to mount when it was found that poor performance could be traced back to poor training. Trainers were also discovering that individuals who overtly participated in a learning situation performed better after graduation than those who were passive observers. As a result, the simulator began to develop from the "mock-up," itself a member of the "model" family. Early simulators required the presence of an instructor but, by 1945, simulators which were almost completely automatic were in common use. The simulator which started as an *instructor-centered* device (audio-visual aid to the instructor) had become a *learner-centered* device. As the variety of simulators developed, the term "training aids" supplanted "audio-visual aids" and this later became "training devices."[6]

This evolution occurred in the military branch of the armed forces. The civilian component of the services and the defense industries did not, in most instances, reach this stage of development for their own training programs by 1945.

Training Device Development to 1960—Industry and business were quick to adapt the lessons of World War II to company training programs. The sound-film-strip, tachistoscope, animated technical film, magnetic blackboard, magnetic recorder and oversize chart are examples of devices which found acceptance. Each of these was essentially an *instructor-centered* device used by the instructor to aid him in communicating.

Closed circuit television, used experimentally by the Navy in 1944, was slow in reaching training programs in industry; In fact, open circuit television has received more attention in recent years because of support from educational foundations and organizations than has closed circuit television for training purposes. However, one *learner-centered* device was developed into a useful *education* tool and that was the magnetic tape recorder. The recorder as a "component" was synthesized into the language laboratory as a "system" and has been widely accepted. As a "system," however, it has not been exploited in *training* programs.

The *learner-centered* simulator remained pretty much as a military *training device* and as an *education curiosity*. Education was slow in applying all of the lessons taught to it by the training experience of World War II.

When the U. S. Air Force, on 26 July 1947, was reconstituted from the Army Air Forces, it faced not only problems of reorganization but a responsibility for defense and attack which involved nuclear firepower, supersonic speed and missile capability to say nothing of space flight. The U. S. Navy, too, entered the postwar period with plans for atomic-powered surface and underwater craft, multi-purpose missiles launched from decks or from underwater and a limitless variety of electronics systems. One of the major training problems facing the Air Force and the Navy, and to a much lesser degree the Army, was to develop raw recruits into electronics technicians who could maintain intricate electronic systems being designed to increasingly complex military specifications. Experimental and engineering psychologists in AFPTRC (Air Force Personnel and Training Research Center), USNSDC (U. S. Naval Special Devices Center) and also under Navy contract at the University of Southern California were grappling with this problem.

In the process of investigating behaviorial patterns of technicians in troubleshooting, i.e.—localizing and correcting malfunctions, a number of variants of the simulator appeared. In addition, simulator variants continued to emerge from the earlier efforts in fields other than electronic systems maintenance training. More and more, the instructor receded into the twilight as the learner and the machine interacted and functioned without the instructor. In 1956, after several years of investigation, the term "pseudo-simulator" was created in an effort to establish an appropriate vocabulary to suit the "total or radical change in thought about training devices."[7] "Pseudo-simulator" applied to "devices which presume to train the learner in skills and knowledge as required by the actual equipment on the job but which neither assume the appearance of the man-machine relationship . . . What then can this device be named? It presumes to satisfy the most essential feature of the simulator without resembling the original object." Examples of the pseudo-simulator were given as the AFPTRC Subject-Matter Trainer, Automatic Microfilm Device and the Malfunction and Circuitry Device; also the Navy's Trainer-Tester, NavPers 92091-1 to -16, a paper and pencil device which sought to develop troubleshooting capability without any apparatus whatsoever.

Briggs[8] believed that "a device like the Subject-Matter Trainer, which has been shown when used alone to permit students to learn certain factual information, would be depended upon in a given course as the sole method by which the student acquires the particular knowledge or skills for which the device is effective"; while Briggs suggested that a substitute term for "pseudo-simulator" be found, he did not provide one. He also stated "that this device, although originally designed for use in connection with Air Force maintenance training, apparently has educational applications of a much broader nature."

The pseudo-simulator obviously was one form of the *teaching machine* which grow out of the "visual aids," "audio-visual aids," "training aids" and "training devices" continuum. For those who desire a definition at this stage, a "teaching machine" is a device which teaches without the presence of a human instructor. Later on, a more specific and comprehensive definition will be proffered.

In the overview, one can see the transition of the simulator from an *instructor-centered* device to a *learner-centered* device between 1945 and 1957. With one or two notable exceptions to be discussed later in this paper, simulators were *special-purpose* machines, that is, fixed-programmed so as to treat only one kind of subject matter.

History of the Teaching Machine Movement 1926 - 1960

The evolution of the "teaching machine" with the "visual aids" origin has been examined. The following excursion will describe the development of the "teaching machine" with "curriculum" or method as the origin.

Pressey, Skinner and the University or Education-Oriented Group—While it is true that auto-instructional devices were patented over 100 years ago, due to his experimentation Dr. Sidney Leavitt Pressey is credited with the formal creation of teaching machine technology when in 1926 he described a device in "School and Society" which was the first educational teaching machine.[9] Pressey received his PhD in psychology at Harvard in 1917 and joined the faculty at Ohio State University in 1921 remaining until his retirement in 1959 as professor emeritus. While he continued to explore teaching by machine, in 1932 it was becoming apparent that the field of *education* was not yet ready for the revolution he had predicted. In 1934, while at Ohio State and probably under Pressey's influence, James Kenneth Little in preparing his doctoral dissertation, published the first systematic appraisal of the teaching machine.[10]

However, it was not until 1954 that an audible voice was added to that of Pressey's in favor of the teaching machine. Dr. Burrhus Frederic Skinner received his PhD in psychology at Harvard in 1931, served on the faculties at the University of Minnesota and Indiana University, and joined Harvard's faculty in 1948 where he is now deeply involved in auto-instructional research. It is clear that Pressey alone carried on teaching machine research in the field of education beginning in 1926 until 1954 when Skinner pubished his famous paper, "The Science of Learning and the Art of Teaching."[11] In this, Skinner describes his experiments in shaping behavior by the use of an "instrument" and by "mechanized instruction." Both Pressey and Skinner visualized auto-instruction as a *method* . . . a curriculum method in which the device was important but incidental to the curriculum. One might say that the "what" or subject-matter was the *content*, the "how" or psychological technique was the *method* and the "way" or machine was the *mechanism*. This is a *learner-centered* concept particularly since there is no human instructor but more significantly because the curriculum is designed around the learning needs of the learner rather than upon the communication needs of the instructor.

In "Teaching Machines,"[12] Skinner states that ". . . Pressey seems to have been the first to emphasize the importance of immediate feedback in education . . . above all he conceived of a machine which (*in contrast with the audio-visual aids which were beginning to be developed*) permitted the student to play an active role . . ."

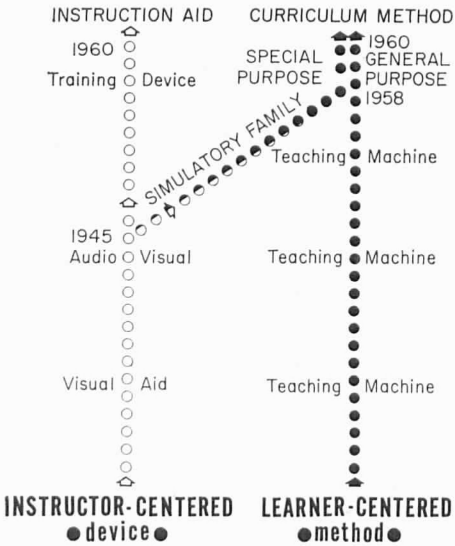

Figure 1

In addition to the differing origins of the teaching machine, one beginning as *instructor-centered* (audio visual) the other as *learner-centered* (curriculum) a study of its evolution reveals a second difference. Simulators and less glamorous kinfolk were used mainly in *training* programs while the original and current efforts by the "university" group are directed to *education* or non-training programs.

Significant Events 1958-60—Inevitably the two separate movements would meet. The first, *formal* meeting of the psychologists who worked on training-oriented teaching machines and the psychologists working with education-oriented curriculums occurred on 8 December 1958 under the sponsorship of the U. S. Air Force Office of Scientific Research at the University of Pennsylvania. Galanter,[13] in publishing most but not all of the papers, said: ". . . most of the papers in this volume generate more problems than they illuminate . . ." but went on to emphasize, ". . . these proceedings are published, not to provide information for the implementation of school or military curricula by machine instruction, but to aid the researcher in isolating parameters for study and to provide him with the currently available information in this field . . ." That the two groups experienced some difficulty in communicating is abundantly clear from Pressey's paper.

Barlow[14] in his review of Galanter's publication discloses some of the "behind-the-scenes" activity when he quotes five outstanding participants as writing: ". . . We regret that we shall be unable to submit our papers to Dr. Galanter for publication purposes . . . We believe that events such as the conference and the information clearinghouse established there serve as sufficient means of communication at the present time . . ." Barlow states that several abstracts were "hardly in a form for distribution to the general public." This conference, "The Art and Science of the Automatic Teaching of Verbal and Symbolic Skills" along with the published papers are, to a degree, responsible for the upsurge of interest in teaching machine technology. It is certain that the psychologists are ready for a full scale investigation of teaching machine technology. Whether the industrial and business world is ready for implementation of the teaching machine is a very good question which probably cannot be answered immediately although an organized array of facts will be presented here for evaluation. Because of its psychological base, nearly all serious investigation is in the university environment. The following institutions are presently known to be so engaged:

Alabama, University of
Arizona State College
Brooklyn College of the College of the City of New York
California at Berkeley, University of
California at Los Angeles, University of
Columbia University
Connecticut, University of
Earlham College
George Washington, University of
Hamilton College
Harvard University
Indiana University
Iowa State College
Kentucky, University of
Loyola University, Los Angeles
New York University
Northwestern University
Oberlin College
Ohio State University
Oregon State College
Pennsylvania, University of
Pittsburgh, University of
Princeton University
Southern California, University of
Stanford University
Temple University
Utah, University of

It should not be inferred that major experimentation is being conducted at each university. An institution is listed if at least one professor has written a paper or, in some tangible manner, has contributed to the teaching machine technology. Obviously, a few schools may have been omitted due to the absence of good communications mentioned earlier.

Teaching machine technology today has all of the characteristics of an epidemic. At least one of the pioneers has stated[15], ". . . The ill-advised efforts of some of our friends, who automatize their courses without adopting the new technology, have an extremely good chance of burying the whole movement in an avalanche of teaching machine tapes . . ." Holland says further[3] ". . . A large number of them (curriculums) are very poorly programmed. Some programmers have taken the trouble to obtain only the most superficial impressions regarding what constitutes a good program . . ." and he believes that teaching machine success can be no better than that provided by the material (lesson plans) prepared for the machines. Levine in an examination of 120 papers in this field concluded, ". . . The essence of the device lies in the way it is programmed . . ."[16]

Regrettably, the field is rapidly becoming saturated with companies and individuals whose sole purpose seems to be to bushwack the unsuspecting "customer" by selling him devices he can't use along with curriculums which may not work based upon untested "principles." This criticism was echoed by Carter[17] who said, . . . "Unless you have a training program, or proper sequence, to go along with the machine, it is no good . . . this is much harder than making the machine itself . . ."

Does Teaching Machine Technology Represent a New Device or a New Method?—Teaching machine technology should be viewed as a trinity: a union of three in one, yet each part retaining individuality.

a. Content	=	subject-matter	Lesson Plan (Curriculum)
b. Method	=	psychological principle	
c. Mechanism	=	machine	

The mechanism, if *general-purpose,* will permit a fixed variety of methods to be used with a nearly unlimited variety of contents. The mechanism is *new* simply because it has never been utilized before. The method is *new* because long approved learning principles which have never reached practical implementation may now be employed. But the teaching machine is *not* an "audio-visual aid" or a "training device." The trinity concept reveals it as a *curriculum method* from which the mechanism cannot really be separated since, by itself, it is not operable—although it exists physically as a tangible piece of hardware.

Holland[3] has evidenced concern because teaching machine curriculums are being prepared by some who are not too knowledgeable about the subject-matter although they may have competence in the psychological area.

Teaching machine curriculums, for some years to come, should be prepared by teams (not committees) consisting of these kinds of individuals shown in Table I for optimization of the effort.

In certain education areas, an experimental psychologist will do no harm and probably some good as a working partner. In certain *training* areas, his counterpart would be an engineering psychologist or one of the new, rare breed: the behaviorial engineer.[3,15]

Definition and Criteria for the Teaching Machine—Earlier the interim definition of "teaching machine" was given as "a device which teaches without the presence of a human instructor."

Here is a more specific and comprehensive definition: "a device which presents a lesson consisting of information actions or objects in a prescribed sequence which are understood, learned and retained by a learner completely without the presence of a human instructor and in which there is an interaction of learner and machine."

Since textbooks, television programs and possibly coin-operated pinball machines might be included under such a definition, one must look for a key word which distinguishes one from another. If, after instruction is provided, there is a method of *measuring* understanding and retention . . . a test . . . then this would differentiate. It is certain that some situations will arise which appear to be covered by the definition and which may not be teaching machine ap-

TABLE I

	Training Programs	*Education Programs*
Content	Expert in the field being trained.	Teacher of the subject or curriculum specialist.
Method	Training Specialist (Psychologist)	Educational Psychologist
Mechanism	Training Devices Technician	Audio-Visual Aids Technician

plications. In such cases, each should be compared with the criteria.

The criteria for a teaching machine

a. instruction is provided for without the presence of a human instructor (self-instruction)
b. learning occurs at the learner's rate (self-pacing)
c. learner receives immediate knowledge of his progress (feedback)
d. there is a participative, overt interaction between the learner and the machine . . . two-way communication is provided (active participation)
e. instructional material and the sequence is carefully controlled and consistent (content and method)
f. reinforcement or reward is used to strengthen learning (method).

It is clear, too, that the mechanism or hardware is incidental since the criteria do not concern it. Yet, one must have a very firm grasp of machine design and operating principles in order to understand the technology.

Development of the Machine

The historical development of teaching machine technology has been discussed. Attention is now directed to the mechanism itself. In order that the machine's function can be better understood, the operation of a *typical* learner-machine interaction is described with several examples of each step.

1. The learner is seated before a teaching machine which has been designated to teach certain material by virtue of its lesson plan.
2. The machine presents information and/or a question or problem (by means of a slide projection, typed piece of paper, tape recording, etc.)
3. The learner responds to the question (by pressing a button next to the correct answer, writing the answer on a sheet of paper, etc.)
4. The machine immediately indicates if the answer is correct.
   a. If the response is correct, a bulb may light, a graph marker may jump, etc.
   b. If the response is incorrect, nothing may happen and the learner must make another selection or more basic information is presented in order to aid the learner in making his selection.
5. The machine presents the next body of information and/or a question.
6. This continues until all the questions are properly answered.

Significance of the Machine—Although the lesson planning is recognized as having the greatest influence on student behavior change, it is believed that the mechanism utilized can strongly contribute to the effectiveness of changing behavior. In order to maintain learner interest, it is necessary that the machine be simple to operate, motivating in appearance and operation, and requiring little or no maintenance. The cost should be kept at a minimum.

Early Multiple-Choice Mechanism—Probably considered the first and simplest teaching machine was Pressey's punchboard developed in the 1920's. See Figure 2. This represented the "multiple-choice" type of machine as contrasted with the "constructed response" type. These two types identify the most prominent difference in learner-machine interaction. The multiple-choice machines display usually 3 or 4 answers one of which is correct and the others of which are incorrect. The learner selects the answer which he believes is correct. In the constructed response type, a question or problem is presented. The learner must recall the information desired and construct his answer based on his previous learning experiences.

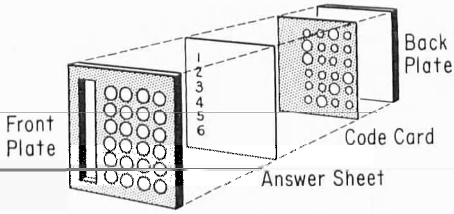

Figure 2. Pressey's Punchboard

Questions and several choices of answers are presented on a separate question sheet. The punchboard consists of a row of identically-sized holes corresponding to the several multiple-choice possibilities, with a list of numbers corresponding to the questions. An answer sheet and answer code card are inserted into an opening in the top and placed directly behind the punchboard. The code card is made of rigid material with small diameter holes under the incorrect answers and large diameter holes under the correct answers. After reading the question, the learner responds by pushing a pencil into the hole on the punchboard corresponding to his choice of answers. If his response is incorrect, the small hole in the code card allows a small hole to be punctured in the answer sheet. If the response is correct, a large hole is punctured in the answer sheet. The number of small holes in an answer sheet indicates the number of wrong responses. Pressey also used another teaching machine in which questions were presented singly in a window and the learner responded by pressing a key corresponding to his selection of alternate answers.

As time went on, other machines using the multiple-choice type of response were developed. Zeaman, used a digital read-out in his machine. The Subject Matter-Trainer developed by the U. S. Air Force Personnel and Training Research Center in 1955, used the matching of the question with one of twenty answers. Today, about half of all commercial teaching machines employ the multiple-choice response mode.

Early Constructed Response Mechanism—In the 1950's Skinner developed a teaching machine[11] which required a "constructed response" rather than the multiple-choice response originated by Pressey. See Figure 3.

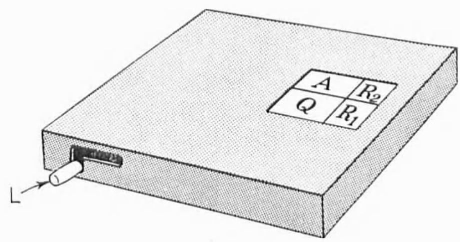

Figure 3. Skinner's Machine

The question or problem appears in box Q1 and after some consideration, the learner writes his answer in box R1, Lever L is then raised by the learner. This causes his answer to move from box R1 to box R2 which being covered by glass, prohibits the learner from changing his original answer. Simultaneously, the correct answer appears in box A. The learner than compares his answer with the correct answer. Later improvements in the constructed response machines involve clues or cues which are made available to the learner if he wishes.

Recent Developmental Trends—The earlier machines were usually hand-powered mechanical devices of very simple design. Moving levers or pressing mechanically-operating buttons usually provided the power desired. Today, the majority of teaching machines use conventional electric power as their energy source. The mechanics of the earlier machines are yielding to electronics for controlling the machines operation. However, mechanical controls are still prevalent in the less costly machines with the accompanying limitation on flexibility. The electronics mechanism varies from the simple, involving only a few electronic components, to the complex involving very elegant digital computers.

The visual display or presentation also has developed over the years. Early machines relied mostly on a printed page. Later, machines were designed to project their presentations onto a screen. Color replaced the existing black and white displays. For the most part, these were rear projections onto translucent frosted screens. Seeking improvement, the designers of the equipment made an effort to enlarge the projected image, maintain clarity and, at the same time, reduce the depth of the machine. Several machines now have provided for aural presentations usually by means of magnetic tape recording. The audio is synchronized with the visual portion of the presentation. A few of the current models have motion picture capability in addition to the conventional still pictures and still another utilizes television-type displays.

No discussion of the teaching machine would be complete without mentioning "programmed text books." These are bound books which incorporate the content and psychological method of teaching machine technology to a degree but do not depend upon a mechanism or apparatus. Certain motivating, reinforcing and overt responding characteristics of the machine therefore may be absent in programmed text-books. It is still undecided whether these can be considered part of teaching machine technology as it is known today.

In order to describe the wide variety of teaching machine characteristics, an inventory has been compiled of known ways by which teaching machines display information, methods of learner responses, and machine indications of correct responses:

A. Displays
   1. Printed 8½" x 11" sheet
   2. Printed Roller Sheet
   3. Printed Card
   4. 35 mm Slide
   5. Filmstrip
   6. Microfilm
   7. 16 mm Motion Picture Film
   8. Magnetic Tape (Audio)
   9. Television (audio-video)

B. Learner Responses (Read-in)
   1. Press One Button of Several
   2. Write Complete Answer
   3. Fill in Missing Word or Letter
   4. Type Answer
   5. Pull Tab
   6. Mark "X" with special ink
   7. Erase Overlay to Reveal Information
   8. Plug Electric Probe into Appropriate Contact
   9. Talk into Microphone

C. Indication (Read-Out) of Correct Response
   1. Green Bulb Lights
   2. Candy is Ejected from Machine

3. New Question Appears
4. Electric Typewriter types Reply
5. Compare Learner Answer with Correct Answer
6. Visual Display on Machine Tells Him
7. Tape Recording Says, "right," etc.

The rate of development of the teaching machine has been phenomenal. There are large and small, simple and complex, and costly as well as inexpensive machines always under development. In time, certain machine characteristics will be used and accepted more than others. These will be retained and the others will fall into disuse and ultimately disappear.

* * *

Part II of this article will appear in the January 1961 Journal and will cover "Concepts and Practices in Lesson Planning" and "The Shape of Things To Come."

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