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ABSTRACT

B.F. Skinner applied his concept of operant conditioning to education. Skinner believed that people acted the way they did because they had been reinforced for behaving in a certain manner. His orientation to pedagogy was predicated upon the notion that a student's behavior could be modified by guiding the student through the learning process using carefully arranged reinforcements. Operant conditioning was the cornerstone of Skinnerian programmed instruction. Skinnerian programmed instruction broke subject matter down into small steps (frames), allowed for self-pacing, and provided immediate feedback. Skinner promoted the use of teaching machines and programmed textbooks. Teaching machines were used to control the presentation of frames, keep records of students' answers, and evaluate, score, and reinforce correct behavior immediately either by controlling and advancing the next frame or by displaying the correct answer. Programmed textbooks presented machine teaching-type learning sequences without hardware. The paper discusses implementation and effectiveness of teaching machines and programmed instruction during the 1950s-60s, noting teachers' and students' mixed responses and describing the eventual demise of this type of teaching. (Contains 58 endnotes.) (SM)

The Use of Skinnerian Teaching Machines and Programmed Instruction in the United States 1960-1970

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The Use of Skinnerian Teaching Machines and Programmed Instruction in the United States 1960-1970[1]

Burrhus Frederic Skinner was a controversial figure of the twentieth century. He was a radical behaviorist who entered the pedagogical arena after visiting his daughter's fourth grade arithmetic class in 1953. After observing the students at work, Skinner was convinced that there could be a better way for teaching children. According to the renowned behaviorist, the teacher was not providing students with immediate reinforcement, which he believed was essential to the learning process. He argued that students needed to be notified immediately of the accuracy or inaccuracy of their work if they were to become successful learners. To Skinner's disappointment, the students were completing arithmetic problems as part of an assignment which was to be collected and scored later by the teacher; hours after the students had finished their work. In addition, Skinner noticed that all of the students were working at the same pace, and on the same problems, despite the fact that some of the children appeared to be more academically advanced. Witnessing these events prompted Skinner to apply his knowledge of behavioral psychology, notably, his concept of operant conditioning to education.

The Psychological Underpinnings of Programmed Instruction

Skinner's research was initially conducted in the laboratory with rats and pigeons. He believed that studying the behavior of lower animals could help psychologists gain insight into understanding human behavior. As a result, the principles of programmed instruction that he espoused represented a transfer of techniques in experiments with animals.

Skinnerian psychology embraces two premises. First, animals and humans are viewed as active organisms that emit various kinds of behavior. Second, when behavior is emitted, it has consequences on the organism's physical and social environments, which in turn, affect the behavior either by increasing or decreasing the likelihood that it will be repeated in the future.

Skinner's views on human behavior differed from those espoused by Ivan Pavlov and John B. Watson. Pavlov and Watson argued that all behavior was reflexive, or that some event (stimulus) had to happen in order for an activity (response) to occur. Although Skinner acknowledged the significance of Pavlovian conditioning, he believed that there were some responses, or behavior, that did not require any eliciting stimuli—the organism just emitted the behavior. Skinner named these behaviors "operants." Operant conditioning is the process whereby an organism's behaviors are strengthened, or weakened, depending on the immediate consequences that those behaviors have on the environment. Skinner's concept of operant conditioning shifted psychology away from its emphasis on the old reflex (stimulus-response) notion of behavior. In essence, Skinnerian psychology underscores "the circumstances under which behavior occurs, the behavior itself, and the consequences that the behavior produces."[2]

Another concept that is crucial to understanding operant conditioning is the contingency of reinforcement, the relationship between a behavior and reinforcement that results in the behavior being strengthened. Skinner believed that if the contingencies were good (positive), the behavior would be strengthened. Conversely, if they were bad (negative), the behavior would be weakened. In order for contingencies of reinforcement to take effect, the following must occur: reinforcements must occur immediately after responses have been made; reinforcements must be made precisely contingent upon performance of the behavior that is being taught; and sufficient numbers of reinforcements must be issued.[3]

Operant conditioning is the cornerstone of Skinnerian programmed instruction. Skinner believed that people do not act because they believe that their behavior will produce a desired goal. Instead, he argued that people act because they have been reinforced for behaving in a certain manner. Therefore, Skinner's psycho-philosophical orientation to pedagogy is predicated upon the notion that a student's behavior can be modified by guiding her through the learning process via the use of carefully arranged reinforcements. Skinner's teaching machines and programmed instruction were designed to implement the principles of operant conditioning.[4]

The Mechanics of Skinnerian Programmed Instruction

During the 1960s, there were different types of programmed instruction.[5] Essentially, the mechanics of the Skinnerian approach were: subject matter was broken down into a sequence of small steps or "frames" with the learning of later steps dependent upon the learning of earlier ones; the student composed a response usually in the form of a short written answer following each item or frame; each of the student's responses received immediate feedback; the student progressed at his or her own rate of learning; the student experienced a low error rate as a result of completing the first four steps; and successful programming was dependent upon the continuous process of testing, evaluation, and revision.[6]

The term "programmers" was used to refer to those individuals who performed tasks associated with the preparation of programmed instructional materials. After the programmers had selected a unit of material to be programmed, they worked on establishing their objectives. Many of them followed the format advocated by Robert F. Mager, who defined instructional objectives in the following manner:

> An objective is an intent communicated by a statement describing a proposed change in a learner—a statement of what the learner is to be like when he has successfully completed a learning experience.[7]

In the Skinnerian type of programmed instruction, the emphasis was placed upon changing students rather than subject matter, and the student was the focus instead of the teacher. Skinner posited that children needed to learn content matter by gradation. He believed that by learning subject matter incrementally, students would gain mastery of simple concepts before advancing to more challenging and complex ones. Skinner and his supporters argued that careful sequencing of information shaped or gradually led students toward the desired goals, by rewarding them for activities that more and more closely approximated those goals. The following is an example of Skinnerian programmed instruction.

1. *Manufacture* means to make or build. Chair factories manufacture chairs. Copy the word here:

   ----

2. Part of the word is like part of the word factory. Both parts come from an old word meaning make or build.

   Manu----ure

3. Part of the word is like part of the word manual. Both come from an old word for hand.

   Many things used to be made by hand.

   ----facture

4. The same letter goes in both spaces:

   m-nuf-cture

5. The same letter goes in both spaces:

   Man-fact-re

5. Chair factories-----------chairs.[8]

The programmers claimed that successful completion of the program by the students demonstrated the students' understanding of the material. Since the students' behaviors were recorded for each frame, knowledge of their understanding of each part of the lesson was easily obtained. For Skinner and his supporters, learning behavior had to take place under the right conditions. Thus, the stimulus was an integral part of the learning process.

Skinner championed the need for having students compose their answers while doing academic work:

> Except in some kinds of stimulus learning, the student should compose his response, rather than select it from a set of alternatives, as he would in a multiple-choice scheme. One reason for this is that we want him to recall rather than merely recognize—to make a response as well as see that it is right.[9]

With Skinner's Disk Teaching Machine students wrote their responses to questions on a small strip of paper tape that was inserted into the machine.

Reinforcement theory was the thread that wove the mechanics of Skinnerian programmed instruction together. Although this theory originated from laboratory research conducted on lower organisms, Skinner and his supporters believed that a transference of its conclusions to human beings offered new insight into addressing some of the educational problems that confronted teachers, such as, getting students to become successful learners. Moreover, they posited that students could be taught to master subject matter by reinforcing or not reinforcing their responses to successive steps presented in an instructional program. They claimed that through the discriminating use of reinforcement and extinction, the program increased the probability that correct responses would be repeated; while incorrect responses would not.[10]

Furthermore, the proponents of the Skinnerian approach maintained that the following two generalizations associated with reinforcement and programmed instruction were true. First, positive reinforcement frequently results in an overall heightening of activity that is useful for instructional purposes. Reinforcement enables the students to be aware at all times that they are learning, and more importantly, to know what they are learning. Also, the use of reinforcement helps the students to view their learning experiences as enjoyable, ergo, motivating them to engage further in the learning exercises. Advocates of the Skinnerian approach claimed that "knowing the correct answer rewards the behavior, gives the learner confidence, and encourages retention."[11] This was pivotal because the reinforcement theory stresses that students learn from the consequences of their responses. In essence, Skinner argued that programmed instruction reinforced the student primarily by acquainting him with the correctness of his learning effort.

Second, Skinner emphasized that the student must earn the reinforcer, and that the reinforcement must be dependent upon a desirable performance. He reasoned that if reinforcements were issued without reference to the student's accomplishment, then there would be now way of knowing what behaviors would be reinforced and therefore learned. Skinner's principal argument was, whatever behavior is in process at the time a reinforcer is given will be affected by the reinforcer. In addition, he stressed that the more quickly reinforcement follows the desired behavior; the more likely the behavior will be repeated. Conversely, Skinner suggested that delaying reinforcement following an action weakens the likelihood that the behavior will be repeated.

It must be noted that Skinner and his supporters did not view the use of reinforcements as bribery. They opined that "the essence of a reinforcer is that it is produced by and is a consequence of, the learner's behavior."[12] In short, the student has to earn the reinforcer.

More importantly, however, the advocates of programmed instruction believed that the type of reinforcer used was contingent upon what the student valued as positive reinforcement. Skinner maintained that it was important to determine what the students liked before any type of reinforcer was used. Rewarding a student with a kind of candy that was displeasing to her might prevent the desired behavior from occurring. Some examples of reinforcers that were and are still being used in classrooms today are: food, gold stars, stickers, or simply the knowledge of being correct.

The proponents of programmed instruction claimed that this teaching medium afforded students the opportunity to work at their own speed. Since the learners were not forced to work at the same pace, they in effect, were receiving individualized instruction. Also, the learners were able to spend as much time on any given frame, or program, as they needed before progressing to new material.

Skinner believed that programmed instruction could help schools become more efficient. The more able students could work through a program as rapidly as they could; while less able students, although taking more time to complete a program, would learn just as much as the more able ones:

> The greatest single source of inefficiency in American education is our practice of moving a whole group of students at the same rate. That's bad for the fast student who has to be held up. He gets bored. But it's particularly bad for the slow student. . .The slow student falls behind in the present system, and then he goes even slower. Finally, he gives up and you lose him. The whole point of individually programmed or prescribed instruction is to move the student along as rapidly as he can or as slowly as he needs.[13]

Knowing the number of correct and incorrect responses made by students as they worked through a program was crucial to the programmers. In the Skinnerian method, the programmers believed that it was unacceptable for the learners to make many errors in completing a program because of the following reasons. First, they believed that making an error eliminated the opportunity for a correct response to be reinforced. Second, there was the danger that the incorrect response would be learned and repeated in the future. Therefore, the programmers adhered to the following rule of thumb: "if students make too many wrong responses—such as more than five to ten per cent of the total—the program is considered a poor one and in need of revision."[14]

Although the programmers acknowledged that there were differences in student abilities, they believed that if most students erred on particular frame, then revision was warranted. However, they were hesitant to assume that a low error rate always guaranteed a good program:

> A good program will be mastered with a low error rate, but a low rate of errors do not automatically signify a good program. The program also must teach the material.[15]

Skinner suggested that a well-designed program made it virtually impossible for students to make errors. The fact that the subject matter was atomized into tiny bits, and presented to students via a sufficient number of easily understood statements guaranteed correct responses in most instances.

A key facet surrounding the writing of programmed instructional materials was the programmer's attention to detail in the designing and revising processes. The writers made every attempt to be precise in their work. It was important to them that every step involved in a student's learning behavior was spelled-out—they left nothing to chance. More importantly, however, the programmers believed that they were accountable for the quality of work produced. The designers did not blame the students if they did not master the subject matter. For them, lack of success was not attributed to the student's inability, but was the result of the programmer's inadequate design. Nowhere is the emphasis on accountability more evident than in the testing, evaluation, and revision stages of programmed instructional materials.

The development of a program was a lengthy process that involved a continuous series of testing, detailed analysis of data, and the repeated trying out of program drafts. Although the programmers may have had their favorite methods of designing and testing programs, they nevertheless, followed some general rules. First, throughout the program development process, students were actively engaged in the testing. The programmers claimed that it was necessary to test each sequence of the program with students of the appropriate age and developmental level. They assessed the students' general abilities as measured by standardized tests. In their opinion, a program that was suitable for one grade level could not be appropriate for another. Also, they believed that students who were participating in the testing process should come from the population for whom the program was being designed. The programmers believed that writing a program for slow learners, and then having it tested with fast learners would have invalidated the results of the program.[16]

Second, after the programmers wrote their first drafts, testing was performed with a relatively small number of students, such as, one, two, or three. Basically, at this stage, the testing involved talking through the programs with the students to identify gross problems of content, sequencing, and results. The writers made changes in the programs according to the students' comments and their responses to questions presented in the instructional frames. A second draft was written to improve over-all effectiveness, and tested this time with a group of four or five students. The testing of subsequent drafts with more students was sometimes needed, in order, to refine phrasing, reduce the language to the bare minimum to do the task, and to do final editing for the printer. The programs were polished and organized in such a way that the writers believed that the programs had validity and could elicit the desired behavior from the students, namely, that they issue the correct response.[17]

Third, once the programs were deemed satisfactory, the writers administered the programs to larger numbers of students through a series of field trials in which evidence of both program validity and learning was gathered. Again, they tested the programs using a sample of students that was representative of the intended population that would be using the programs in the future. The initial trials helped the programmers identify and remove gross errors. In addition, the programmers were cognizant of the fact that field trials made in one socioeconomic community could not be valid for another. As one experienced programmer stated, "this factor, too, needs consideration."[18]

Keeping accurate records regarding field trials was a vital concern to the programmers. They championed the need for having qualified experts in the field supervise and conduct the trials. After undergoing a series of field trials, the programs approached their final form, and validating tests were administered to gather data on the performance characteristics of the programs as a whole. The validation tests were given to the populations for whom the programs were intended.[19]

When programs were ready for use by the intended population, the programmers began a series of tests to determine their effectiveness. In general, the programmers used pretests to measure the achievement standard of the student in the subject area before the student attempted the programs, and post-tests to determine achievement after the programs had been used.

Testing students before and after completing the programs provided a baseline against which student performance could be assessed. Scores on the post-tests were compared to those achieved on the pretests in order to determine if using the program had helped the students learn the content matter successfully.[20] The designers suggested that a net gain between tests could indicate that the program had helped the students learn. In essence, the primary function of testing was to improve the program.

In program development, evaluation was the process by which the programmer made judgments or decisions regarding a program and its effectiveness. These judgments were based on the collection and analysis of data gathered from the administering of objective tests, observations, and the reviewing of anecdotal records. In short, evaluation focused on the length of frames, topic coverage, patterns of repetition and review, modes and frequency responses, error rate, and the procedures and scheduling of reinforcement. At this stage, the programmers asked themselves the following questions: Did we include all the behaviors selected as appropriate and provide practice in discrimination between the appropriate and inappropriate behaviors?; Did we provide for practice in appropriate contexts so that the correct responses would follow the correct stimuli? and Did we provide so complete an explanation of all the ideas and concepts that no challenge was experienced by the students?

In programmed instruction, the student was, in a sense, the final authority in determining whether or not a program was good. The programmers examined the nature of the students' responses in an attempt to ascertain the effects of the programs on the students, and revised their programs according to the results obtained. The process of revision almost always lengthened the program.

There were instances when the programmers had to face the possibility that the ineffectiveness of their programs was due to their lack of sufficient understanding of a particular subject. When this was the case, they sought help from individuals who were more qualified to make the needed revisions.

Skinnerian Teaching Machines and Programmed Textbooks

A teaching machine was a device that controlled presentations of the frames, kept a record of the student's answers, attempted to evaluate, score, and reinforce correct behavior immediately either by controlling and advancing the next frame, or by displaying the correct answer. Programmed instruction was simply the unit of material to be learned. The material was presented on a disk or celluloid tape and threaded into the machine.

One of the most misunderstood aspects surrounding the teaching machine in the 1960s was its purpose for having been invented. The notion that teaching machines were going to supplant classroom teachers dominated the discourse. Granted, Skinner did suggest that teachers who could be replaced by teaching machines should be. However, he was referring to those educators who were performing their duties unsatisfactorily. If a teacher was very ineffective, and if a teaching machine could do the job better than she did, then she should be replaced.

In the 1960s, Skinner wrote "in assigning certain mechanizable functions to machines, the teacher will emerge in his proper role as an indispensable human being."[21] He believed that with all the social pressures that confronted teachers in the classroom, instructors needed instrumentation to help them achieve their goal, namely, to teach effectively. Skinner wrote, "adequate apparatus has not eliminated the researcher, and teaching machines will not eliminate the teacher. But both teacher and researcher must have such equipment if they are to work effectively."[22]

Skinner's first teaching device, the Slider Machine afforded students drill and practice in mathematics (Fig. 1).[23] With this early model, the learners already knew how to compute problems before using the machine. If the students wanted to use the device, they brought a stack of cards to it. Inserting a card into the machine made a problem appear in the window. The students moved sliders to set the digits of their answers in the space provided to the right of the problem. When the students were ready to learn the accuracy of their answers, they pressed a button, which caused the sliders to lock in place, which in turn, made a light appear. If the students' answers were correct, the light showed through a hole in the card enabling them to read the answer. The students could then advance to the succeeding problem by exchanging the card in the machine with another from the stack. If the answers were incorrect, they could not proceed, and they had to pull a lever that allowed them to rearrange the sliders, so that they could try again. In essence, the Slider Machines required students to compose their answers, and supplied immediate feedback to the students regarding the accuracy or inaccuracy of their answers, but without revealing the correct answer in case of error. Also, the machines allowed students to work at their own speed.[24]

Skinner's second device, the Disk Machine was small enough so that it could lie on top of a student's desk (Fig.2).[25] This model contained a large twelve-inch paper disk on which the questions and programmed material were printed. The disk, which resembled the 33 1/3 rpm record album, could be rotated exposing each question in turn, in a slot at the top of the machine (Fig. 3).[26] The student wrote her answer to the question in each frame on a strip of paper tape that was included in the machine. Once she wrote her answer, she moved a lever in her left hand to check it. Moving the lever caused the answer to be covered with a glass plate (preventing her from changing it) and exposed the correct answer to the question. This lever also punctured the paper to record her answer, whether she had judged it to be correct or incorrect. If she answered accurately, then another lever was moved by the student exposing the next question in the sequence. If her answer was recorded as inaccurate, then the disc revolved a second time and presented the question to her again. After finishing the disk, she removed the strip of paper, read the results of her performance, and placed it in a file to record her progress. The teaching machine was designed so that the disk could be rotated until the student had responded to every question accurately on two separate attempts. More importantly, however, the Disk Machine always provided the student with the correct response even though an error had been made.[27] This feature was not present in the Slider Machine.

The Disk machine executed the mechanics of Skinnerian programmed instruction by: presenting subject matter to students in an atomized sequence of small interactive steps; requiring students to compose a response; providing immediate feedback; allowing students to work at their own rate of learning; enabling students to experience low error rates; and allowing for the continuous process of testing, evaluation, and revision.

Programmed Textbooks

In addition to teaching machines, programmed instruction involved the use of programmed textbooks. The programmed textbook was a "simple means for presenting machine-teaching type learning sequences without hardware."[28] Although programmed text materials were used without teaching machines the programmed text materials that were designed according to the Skinnerian approach still followed a small-step, constructed-response program.

Although the external appearance of the programmed text resembled that of an ordinary textbook, its interior was very different. Programmed textbooks were designed according to a horizontal or vertical format. In a book of a horizontal design, the presentation-answer-feedback cycle of the program was accomplished by turning the pages of the text one at a time in the regular manner. Every page consisted of approximately four or five frames and the sequences of the frames were not arranged from the top of the page to the bottom as in a conventional workbook. Working through a program required the students to begin by reading the first frame presented in the top row of page one, make a response, and turn to the top row of page two to confirm their answers. To proceed to the next presentation, the students turned to page three, read and responded to the top frame, and confirmed their answers by turning to the top of page four. This process continued until the students completed the end of the chapter, where they were instructed to return to page one and begin responding to the frame below the top frame on each page. The students continued working until they had concluded the program. All frames were numbered in order to prevent confusion. In the vertical format, the correct answer was presented either beside or below the frame. This format required the students to voluntarily cover the answers with a piece of paper or simple masking device.[29]

The Implementation of Teaching Machines and Programmed Instruction

During the 1950s, Skinner's work was funded in part by the National Defense Education Act of 1958 and various foundations.[30] Later in the 1960s, Skinner received grants from the U.S. Office of Education and the Carnegie Corporation. With the financial assistance provided by the Federal Government, the use of teaching machines and programmed instruction in U.S. schools gained momentum. Also, industry took notice of programmed instruction and teaching machines. Obviously, there was the hope that these teaching devices would "catch on" and yield huge financial profits. A 1961 *New York Times* business report suggested, in this regard:

> Uranium, Canadian oils, computers, boats and book publishing are some of the industries that have captured profits and investor interest since World War II. Now, a new one may be added to the list—teaching machines.[31]

Companies, such as American Telephone and Telegraph, General Dynamics, and Eastman Kodak began to experiment with programmed instruction, for training their own employees. Also, many standard publishers, notably, Prentice-Hall, Grolier, Encyclopedia Brittanica, and Science Research Associates (SRA) "plunged into automated teaching on a major scale."[32]

In 1962, there were sixty-five companies designing programs and fifty-nine companies manufacturing teaching machines across the United States. The state of California led the country in the manufacture of the machines, while New York designed most of the programs.[33] The brainchild of Skinner and others had indeed become an industry.

Teaching machines and programmed instruction were employed in U.S. universities, secondary and elementary schools, and adult education programs throughout the Northeast, the Midwest, and the Southwest.[34] The new technology was being taken seriously by many in the field of education. However, after having reviewed much of the literature, it appears that universities and school districts used the technology on an experimental basis only. Also, universities and school districts that opted to experiment with these instructional mediums did so on a minor scale. The research indicates that no university or school district adopted the technology as a standard medium for instructing all students. In fact, the schools that did experiment with teaching machines and programmed instruction had only certain numbers of classes participating in the experiments.

Furthermore, it appears that many of the schools that did elect to use the technology shared a common theme. In short, their students were not learning the content matter successfully via conventional instruction. Therefore, the school administrators and teachers felt that there was a need for seeking out innovative teaching methodologies. When using programmed instruction and teaching machines, however, most of the schools' personnel were cautious about interpreting student achievement as an indicator for the technology's success or lack of.[35] Administrators and teachers were simply trying to find new modes of instruction that might help their students learn more effectively. For them, determining whether teaching machines were more effective than conventional teaching practices was not their primary objective. There were several studies conducted in classrooms where the new technology was compared to conventional teaching practices. However, the need to ascertain if teaching machines could outperform conventional methods of instruction was of major interest to individuals working primarily in higher education, or who were actively engaged in the fields of psychology and technology.[36] The major concern of the school principal and classroom teacher was: "Is this new technology going to help my students? In many of the reports and studies, the teachers often stated that if the technology was not working or was having adverse effects on their students they would discontinue using the teaching machines and programmed instruction immediately.[37]

Moreover, the research associated with the use of teaching machines and programmed instruction in schools reveal that many school systems preferred designing their own programs to purchasing commercial programs that were available on the market.[38] In general, the school districts' personnel believed that by designing their own programs, they would be addressing the unique concerns of their communities. The administrators and teachers argued that they were in a much better position to determine their students' needs than a publishing company in New York City. Therefore, teachers were often trained via workshops and summer camps to design instructional programs. They, in turn, would return to their respective schools and impart what they had learned with the other members of the faculty.

The literature contains many studies in which teachers used the technology in their classrooms, and then reported their findings.[39] When teaching machines and programmed instruction were implemented in classrooms, they were used primarily by teachers who were willing to experiment with the technology.

Perhaps the most interesting feature surrounding the use of the technology is that school systems by and large were interested in some of the concepts underpinning the use of teaching machines and programmed instruction, but not with all of the principles associated with program design. To some educators, the concept of positive reinforcement and the notion that students would be working at their own rate were most appealing. However, the educators were not concerned with following the exact rules of programming. Instead, they added their own "signatures" to the programs. For example, instead of designing programs based on a series of atomized steps, content matter was sometimes provided in larger increments to students in an attempt to avoid the boredom issue which was the major complaint associated with the use of teaching machines and programmed instruction. Also, some schools designed programs that presented a combination of the Skinnerian format of responding (constructed response) with the Crowderian (multiple choice) format. The School Mathematics Study Group stated in their final Programed Learning Project Report that "an examination of programed materials that are feasible and promising should include such hybridization for consideration."[40] In the early 1960s, it was more popular to use commercial programs, but as time progressed, and as more educators were becoming involved with the new technology, the desire for producing locally designed programs grew.

Although teaching machines and programmed instruction were used experimentally for providing regular instruction, enrichment, and remedial instruction at the university, secondary and elementary school levels, the research indicate that programmed instruction was used primarily as enrichment or supplementary instruction.[41] The teachers who used the technology in this manner believed that students who wanted to learn more about a subject could do so by working with programmed instruction independently.[42] In Texas, for example, programming was used most often for enrichment or supplementary purposes with remedial work a close third. Of the total 315 schools that were implementing programmed instruction during 1965 to 1966, 178 schools used the technology for enrichment, 159 for supplementary, and 151 for remediation.[43] As the numbers indicate, some of the schools used the technology for more than one purpose. Moreover, in a survey of all public elementary and secondary schools, which were using teaching machines and programmed instruction in Pennsylvania during 1962-1963, it was suggested that "programmed materials should be utilized as supplementary material rather than as the basic instructional agent."[44]

Teacher and Student Reactions

As with other pedagogical innovations, teaching machines and programmed instruction had their share of supporters and detractors among the teaching profession. In general, teachers believed that programmed instruction should be used alongside other teaching practices. The data reveal that while some teachers may have viewed the new technology as innovative, others found it to be aversive.[45]

Those teachers that did support the new technology were quick to suggest that although programmed instruction was not an educational panacea, it did have its merits. For example, some teachers applauded one of the underlying principles of programmed instruction, namely, that students could proceed at their own rate of learning. As one retired teacher who used programmed instruction for teaching algebra wrote:

> The basic tenet of allowing students to work at their own pace was good.
>
> The self-motivated ones were able to hold and accomplish what they wished in a fraction of the usual time. The unmotivated ones wasted great amounts of time and were bored after the repetitious step by step routine replaced the usual class interaction opportunities.[46]

In addition to allowing students to work at their own pace, some teachers enjoyed working with programmed instruction because it afforded them the opportunity to work with individual students, or small groups.[47] In some studies, when a student completed a program, and completed a test over the materials, it was graded. Then a ten-to-twenty minute conference was held between the student and the teacher. Meanwhile, the other students in the class were busy working through the problems. The teachers who enjoyed this aspect of programmed instruction believed that students benefited from receiving immediate feedback to their responses. They argued that via programmed instruction, the teacher was able to identify areas of weakness, discuss various ways of problem solving, and develop topics for future study with individual students. Also, the teachers stated that they were relieved of some instructional tasks, such as, presenting information, monitoring student activity, and grading students' work. The teachers believed that they were able to devote time to more challenging tasks, including, clarifying, analyzing, synthesizing, and generalizing from the basic content presented by the program.

Conversely, teaching machines and programmed instruction had their share of detractors. For some teachers programmed instruction was an instructional medium that isolated students from their teachers and their peers. In short, they believed that the new technology did not allow teachers to engage in student learning, and that it reduced their role to that of a monitor who simply facilitated the use of programmed materials. For some of these teachers, programmed instruction was a cold and dehumanizing approach to learning because it did not take into account the affective needs of their students. Also, some teachers claimed that the notion of having students working at different levels and at different places in the program made them feel uncomfortable. Some teachers believed that if students were allowed to work at their own pace, they would take too long in completing an exercise.[48]

Another complaint of teachers surrounded the technical aspects of the teaching machines. For example, in the early years of the technology, teachers were hampered by the fact that once a program was entered into the teaching machine, it could not be turned back, and the student could not easily refer to previous questions or answers. If a student wanted to review a particular frame, she would have to insert the program again, and go through each of the frames until she found the one she needed. The teachers felt that this was an unnecessary restriction. Another complaint was that for some types of teaching machines the window through which problems and derivations were presented was so small that any lengthy derivation became too cramped. As one teacher stated, "You need a microscope to see the text. Similarly, the answer space was too small for anything but the shortest answers."[49] In response to such criticism, designers began constructing machines that made it easier for retrieving particular frames, and that provided larger spaces for written answers.

Although teachers, in general, did not support teaching machines and programmed instruction, it is my contention that their resistance toward teaching machines and programmed instruction was based in part on a lack of understanding. In many instances, teachers were mandated by school district administrators to use the new technology without any training. Therefore, it is reasonable to assume that for those teachers who were forced to use the technology, resentment toward teaching machines and programmed instruction would have been the end result. If more of the school districts that experimented with the concept of programmed instruction had allowed their teachers enough time to learn and explore this mode of instruction, prior to its implementation, more teachers might have supported the concept. In fact, some of the teachers who enjoyed using programmed instruction suggested that teachers should not be forced into implementing the new technology. As one teacher of the Brigham Young University Laboratory School in Provo, Utah stated:

> We found out, too, that a lot of the districts that have come to see us have teachers steeped in conventional methods of teaching and with no real background for programmed instruction. The administration simply wants to hand them these programed materials and say, 'Do what you can.' I think nearly all the teachers—not all, but nearly all of them—have had a defensive attitude toward programed teaching because all they can see is more problems for themselves. For example, we had a teacher come down from Idaho and he said his superintendent wanted him to jump into it before the end of this year. Well, just to set up the testing program for one class would take a whole summer of work for him. Yet, the superintendent wanted him to introduce programed materials during the last three months of the year. We told him to do anything—get

down on his knees and beg, if necessary—but not to attempt the job because it would create attitudes toward programed learning that they might not be able to overcome.[50]

After reviewing many studies, it was evident to me that it was the classroom teacher who helped set the stage for the implementation of teaching machines and programmed instruction. When a teacher had a positive attitude toward these instructional mediums, her experience with them tended to be positive. Conversely, when a teacher had a negative attitude, her experience with teaching machines and programmed instruction tended to be negative as well. In some of the studies, the researchers reported that teachers "griped loudly about the materials in front of the class."[51]

One of the major arguments supporting the use of teaching machines and programmed instruction was that these mediums allowed students to proceed at their own rate of learning. Advocates of the new technology posited that since a student could work at her own pace, she would not feel the pressure of having to compete with her peers. After reviewing several studies in which teaching machines and programmed instruction were utilized, however, competition among students was still evident. Many of the students still experienced the pressure to keep up with other students. In short, they did not want to appear "dumb" in the presence of their peers or instructors. Having to repeat a program due to their inability to attain the level of mastery required made the students feel pressured to succeed the first time they worked through a program.

In addition, some students stated that in competing with each other for speed, they were forced to proceed through the program at a rapid pace without gaining an understanding of the content.[52] In this situation, a student was not working at her own rate of learning, but was proceeding at the pace established by the other students in the class. Clearly, this is not what

Skinner or his supporters had in mind. Nevertheless, competition was a significant factor for some students. It must be noted, however, that there were students who enjoyed working with teaching machines and programmed instruction because they could proceed at their own rate of learning. They did not experience any pressure to succeed during the instructional exercises.

One of the most interesting patterns that emerged after having reviewed over sixty studies is that students at the university, secondary and elementary grade levels who were using teaching machines and programmed instruction did not feel that they were being dehumanized. The data reveal, however, that is was the adults and not the students that objected to the technology on the basis that it produced dehumanizing effects on learning. One might have imagined that the young children or adolescents who participated in the studies would have expressed these sentiments primarily. The younger children might not have used the terms, "cold, impersonal, or dehumanizing." However, they still could have used words that denoted a similar meaning, such as "learning like this is not fun," or "I want to go back with my teacher and my friends." However, in the studies involving younger children, complaints of this nature did not appear. In fact, the elementary students expressed more favorable comments about the teaching machines than the older students did.[53] Naturally, the novelty factor played an important role. However, even after the younger children had had enough experience with the mechanical devices, many still expressed positive comments. Also, in several of the studies in which high school and university students were involved, the majority of students did not express the "cold and inhumane" sentiment either. However, for the few that did, they stated that they disliked the feeling of just being in an experiment.[54]

It appears that for the most part, criticism of the technology did not come from the students, but stemmed from forces outside the classroom. Primarily, the detractors of teaching machines and programmed instruction came from the fields of psychology and education. In short, the detractors believed that this particular approach to education prevented students from interacting with their teachers and peers.

The Effectiveness of Teaching Machines and Programmed Instruction

During the 1960s, the need to determine the effectiveness of programmed instruction was paramount to those involved in higher education and educational technology. Many studies comparing the new technology with conventional teaching practices were conducted. The data reveal that, in general, programmed instruction at the elementary, secondary, and university levels was not any more or less successful than the conventional teaching methods of the 1960s, notably lecture and textbook instruction.[55] However, there were studies where the use of teaching machines and programmed instruction was deemed more successful than other teaching practices.[56] Conversely, there were other studies in which the new technology was deemed less effective.[57] However, as a whole, it appears that programmed instruction was just as effective as the more conventional forms of instruction. In those studies where teaching machines and programmed instruction were more effective than regular classroom instruction, two variables were almost always present. First, programmed instruction was not the sole instructional medium used to present content matter. Textbooks, class instruction, group discussions, filmstrips, or workbooks accompanied the use of programmed instruction. Second, the teacher who experimented with the technology possessed a more favorable attitude toward programmed instruction.

Programmed Instruction's Fall From Grace

Researchers attribute the demise of the teaching machine movement to three major factors. First, in keeping up with the demand for new programs, many programmers ignored the mechanics of programmed instruction and began producing inferior programs. Second, school districts did not find the new technology to be cost effective. Administrators believed that the cost for implementing teaching machines and programmed instruction in schools would be astronomical. Third, the education establishment as a whole did not embrace these modes of instruction. In addition to viewing the technology as dehumanizing, many educators believed that the technology provided only rote learning and did not promote creative thinking. Although the term programmed instruction is no longer used, the mechanics of programmed instruction are still being implemented in current teaching practices, notably precision teaching, direct instruction, the personalized system of instruction, and cybernetic instruction.[58]

Conclusion

The history of American pedagogy involves a long tradition of endeavors to improve the quality of education and to make it more efficient. In keeping with this tradition, Skinner and his supporters believed that by making teaching and learning more scientific, educators could possess a blueprint that could enable them to teach students more effectively. They posited that using this blueprint would guarantee all youngsters the opportunity of receiving a good education, which in turn would ensure an erudite and productive citizenry.

Had Skinner worked with teachers in promoting teaching machines, the technology might have encountered less resistance in the pedagogical arena. Ironically, Skinner did not work with teachers, the very group of individuals that he was trying to help. Seeing Skinner working with groups of teachers who were using teaching machines in their classrooms might have demonstrated to his detractors that he was indeed interested in helping educators. Also, had he conducted teacher workshops on the technology, his message might have reached educators directly minimizing the possibility of being misunderstood. In essence, it was the programmers and Skinner's supporters that were responsible for promoting the idea of programmed instruction to the public, and were often the people who had to face the negative comments from teachers, school administrators, and concerned citizens at the ground level.

Moreover, the research demonstrates that Skinner was the guru behind the concepts of Skinnerian programmed instruction. In general, however, it was the programmers who worked to improve the quality of programming and not Skinner. A significant fact regarding Skinner's role in the teaching machine industry is that he did not design many programs himself. Most of the literature on programmed instruction that focused on program development, notably, the testing, evaluation, and revision processes were written by others.

Endnotes

[1] I would like to thank the following individuals for their assistance in helping me locate sources: Peggy Aldrich Kidwell, Museum Specialist for Collections of the National Museum of American History; Cathy Woodrow, education specialist for the Reference Dept. of the Library of Congress; Olivia Aguilar Gattis, archivist of the National Education Association; the staff of the Harvard University Archives; and the late Donald A. Cook, a designer of teaching machines and programmed instruction in the 1960s. In the literature, programmed instruction is often spelled as "programed" instruction with a single "m." I have opted to use the double "m" spelling of the word throughout this paper, except when citing research material that uses the single "m" spelling of the word.

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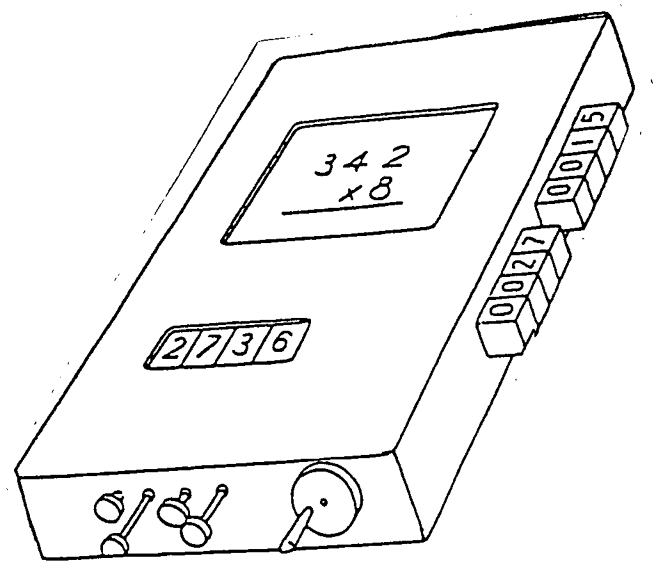
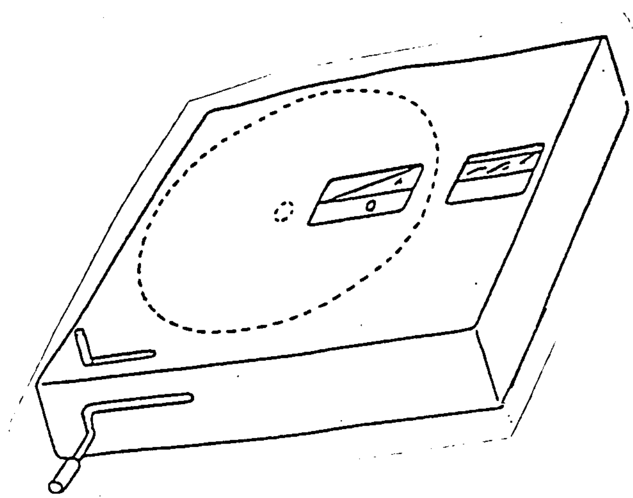
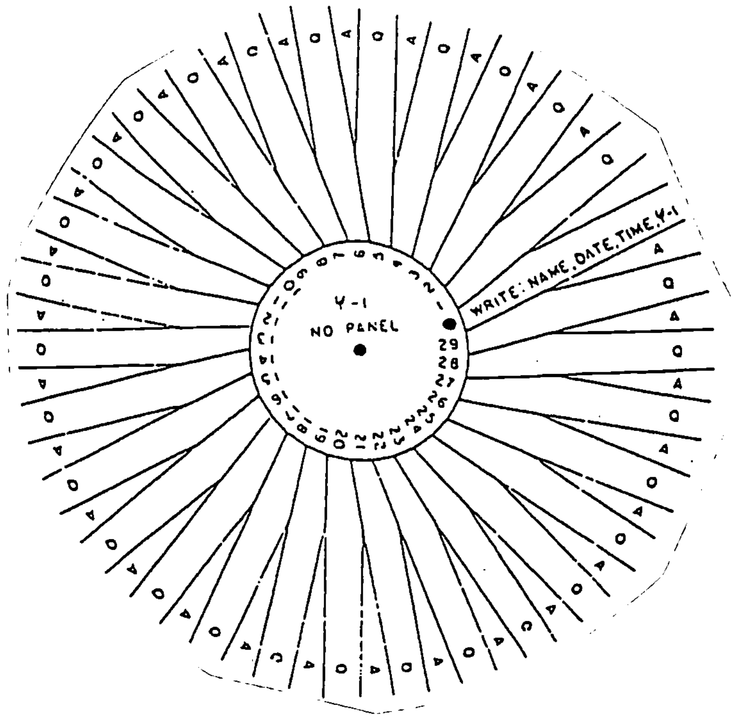
(Fig. 1) The Slider Machine



(Fig. 2) Disk Machine



(Fig. 3) Program Disk for the Skinner Disk Machine



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