Hauptlinien und Kernfragen der internationalen pädagogischen Entwicklung

Bericht über eine Pädagogen-Tagung
vom 17. bis 26. März 1962
im Internationalen Haus Sonnenberg
bei St. Andreasberg/Oberharz

UNESCO-Institut für Pädagogik,
Hamburg

Internationaler Arbeitskreis
Sonnenberg, Braunschweig

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AUTOMATED TEACHING. THE STATE OF THE ART

Introduction:

There are more and more so called teaching machines. Most of them are prototypes but in a few cases they are already being sold just like books. For instance, Grolier Inc., New York, one of the most important publishers of Encyclopaedias in America intend to sell many thousand teaching machines this year at a price of Dollar 20 each.

Actually, it is not surprising that so many people are interested in teaching machines.

The main reasons are: teacher shortage in developed and developing countries, the desirablity of more efficient teaching; teaching machines can also be used for research purposes.

I think that educators ought to keep an eye on what R. Price considers as one of the „great educational advances of recent years". Carpenter said two years ago: "Despite the lack of sufficient data, the machine learning movement appears to be the most promising development in education since the turn of the century".

Definition:

Though the expression "Teaching Machine" is already used all over the world, it seems that "Self instructional Device" would be more appropriate.

Carpenter defines the teaching machine as "any mechanical or electronic apparatus which presents learning material in small segments, each segment calling for a response, which is followed by some knowledge of results". Fattu has drawn attention to the difference between teaching machines and other teaching aids. "TM", he writes, "are concerned with the entire Teaching cycle: presenting material to be learned or tasks to be done, providing for learner activity, and correcting errors or shaping responses. In contrast, teaching aids (...) are (only) concerned with the presentation phase of teaching".

Classification:

The T. M. is not so new as one would imagine. Educative toys already in existence in the 19th century and in the early years of this century may be considered as forerunners of some of the present self tutoring devices.

But, history is not so important here and we want to have a look at the present state of the Art. If we try to classify the machines known so far, we can identify two main *classes:*

I. *Non-adaptive machines*
II. *Adaptive machines*

Furthermore, let us mention that most of the research and the literature available concerns the first class and that here two main groups can be identified:

the Pressey group,
the Skinner group.

I. *The non-adaptive machines.*

A. *The Pressey Group* — "response selection machines".

Sidney Pressey has been working on machines of this sort since World War I. Pressey had three aims in mind:

— to attain more objective scoring of tests
— to try to reduce the burden of scoring
— to teach or drill informational material by mechanical means.

In fact, Pressey's machine is an automated, mechanical multiple choice question test. In March 1926, Pressey described his device in an article published in „School and Society" under the title:

A simple apparatus which gives tests and scores — and teaches:

> "The apparatus is about the size of an ordinary portable typewriter — though much simpler ... The person who is using the machine finds presented to him in a little window a question in the ordinary selective-answer type. To one side of the apparatus are four keys. Suppose now that the person taking the test considers answer four to be the correct answer. He then presses key 4 and so indicates his reply to the question. The pressing of the key operates to turn up a new question. The apparatus counts the number of his correct responses on a little counter to the back of the machines."

Immediate feedback consists generally in the knowledge of right or wrong. For instance, the machine will not turn to a new question as long as a correct answer has not been given to the previous one.

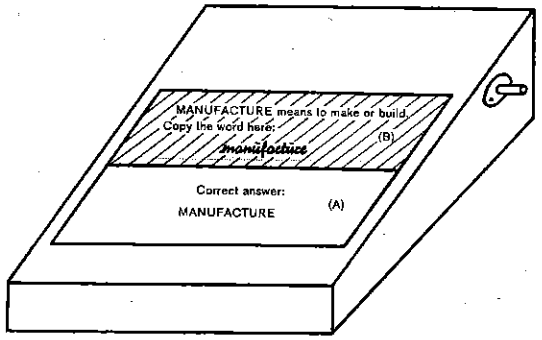
No real interest was evoked by Pressey's device till World War II. His machine was then used by the American Navy to teach factual information.

There is not much to say about the devices of the Pressey group. They have limited ambition but can do very efficiently what they are supposed to do.

B. *The Skinner Group:* — "response construction machines"

I class in this group all machines — and there are many — built according to Skinner's theory.

The aim is here more ambitious since the machine wants to be a real teacher. Skinner's basic device is as follows:



We have a box with a glass window (B) and an open window (A). The question appears first in the open window. The student writes his answer, then pulls the crank. His answer moves underneath the glass, and the correct answer appears in its place.

The important thing is of course the *program* that is inserted into the machine.

It is printed on sheets, or on discs, cards or tapes. If the student sees that he has given a correct answer, he pushes a button and punches a hole in the program. When the program is completed, the student starts again from the beginning but the machine stops only for the question for which a wrong answer was given. The correction can also be fully automated.

Skinner's learning theory.

Skinner has done a lot of animal training (his piano playing pigeons are famous) and he applies the results of his observation to a theory of human learning, the main features of which are as follows:

1. Any behaviour to be shaped, should be devided into small parts in order to make success as easy as possible.

(If he wants a pigeon or a dog to execute a figure eight, he starts rewarding him for any motion, then only for any walking in a curved line, then only as it adjusts its path to the pattern desired.)

2. The learner sits alone in a booth: his attention is focused on the problem to be solved. This is not unlike conditions in a conditioning laboratory.
3. The learner knows immediately whether his response was correct. In other words, he is rewarded and his behaviour is reinforced by this reward.

EXAMPLES OF PROGRAMS

PART OF A PROGRAM IN HIGH-SCHOOL PHYSICS by Skinner (1958)

Sentence to be completed	Word to be supplied
1. The important parts of a flashlight are the battery and the bulb. When we "turn on" the flashlight, we close a switch that connects the battery with the	bulb
2. When we turn on a flashlight, an electric current flows through the fine wire in the . . . . and causes it to grow hot.	bulb

ITEMS FROM A PSYCHOLOGY PROGRAM by Holland (1960)

Item	Correct answer	Percentage of students giving the answer
1. Performing animals are sometimes trained with "rewards". The behavior of a hungry animal can be "rewarded" with	Food	96
2. A technical term for "reward" is reinforcement. To "reward" an organism with food is to . . . . it with food.	Reinforce	100
3. Technically speaking, a thirsty organism can be . . . . with water.	Reinforced	100

PROGRAM SAMPLES FROM *Modern Mathematics: A Programmed Textbook* by L. Eigen, J. Kaplan and R. Emerson, 1961.

1. The numbers we use to count with are called "countig numbers" or "*natural numbers*". 0, 1, 2, 3, etc. are natural numbers. 1/2 is not a natural number.
   Is ¾ an natural number? . . . . (Yes-no)

   no

2. 0, 1 an 2 are natural numbers.
   3, 4, 71 and 10,001 are also . . . . numbers.

   natural

Advantages claimed for the machine [1])

1. The learner must learn an item or a lesson thoroughly before he can proceed to the next one.
2. The progression from one item to the next is under the control of the learner.
4. Learning becomes easy.
5. The frustration caused by failure is eliminated to a great extent.
6. The learner is strongly motivated by the machine itself and by the success it makes possible. George Price writes: "The teaching machine may provide a new and better source of motivation to make children work hard and at the same time make their study so pleasant and effective that even the dull ones can learn hard subjects without frustration".
7. McNeil thinks that the TM "extends one's ability to conceptualize through the use of the Socratic method, which requires that the learner makes "progressive discriminations".
8. TM promise to relieve the teacher of much routine work so that he will be able to devote more time to psychological studies, to observations of the childern, etc. . . .
9. The detailed record of the pupil-performance will help to identify learning difficulties.
   etc.

A critical look at the Skinner system.

About motivation.

Apparently, deep motivation does not seem very important to the Skinner school. As a matter of fact, they seem to believe that the motivation comes from the subject matter itself or from the easy success or progress of the learner. What are those sources of motivation worth?

1. We are not at all sure that the subject matter offered in the programs we have seen so far will specially attract the students.
   Questions look sometimes like quiz and the interest for such a game is not necessarily a lasting one.

[1]) Among others, see CARPENTER.

We do think that the normal process of motivation is from the child to the subject matter and not from subject matter to the child.

2. What about the easy success and progress?
   We are not at all sure that the same amount of reinforcement is needed to shape a human being's behaviour as to train an animal. Skinner himself is no longer so positive about this as he was two or three years ago.

Furthermore, generalizations are dangerous as usual. Thompson and Hunnicutt have shown experimentally that the same praise or blame have not the same effect on the work achievement of introverts and extroverts.
Of course, much more experimentation is needed but we have reasons to be careful.

Since the subject matter is divided in very small bits and the pacing is very slow, the student has not much challenge. I do not think that education must be deliberately made difficult, but to learn . . . you must at least be awake. Furthermore, in real life the problems we have to solve neither come the easy way nor in bits and pieces.

"This is indeed a problem", Skinner writes. "All good teachers must "wean" their students, and the machine is no exception. (. . .) The final stage of a program must be so designed that the student no longer requires the helpful conditions arranged by the machine (. . .) These are questions which can be adequately answered only by further research." This is not much of an answer.
Skinner also wrote: "If we can solve the motivational problem with other means, what is more effective than giving a point away?"

Three remarks are necessary here:

1. I do not think that real motivation can be replaced by totally artificial means.
2. When Skinner speaks of what has been easy learned, we may wonder what he means by learning.
3. I think that hard work and even frustrations are needed — in reasonable amounts — in education.

My conclusion so far is that Skinner neglects the best part of motivational forces in education.

About learning.

What is teaching machine learning worth?

The danger here is a confusion between learning and performance. As Bayles tells us, "learning is really a change in insights. It is not a mere response or a set of responses to the world of knowledge (. . .). Knowledge has to be patterned, not piled item on item." In other words learning implies a personal integration of knowledge and rearranging of the mind.

It has been said that the TM extends one's ability to conceptualize. Kneller notes with Gagné that we deal with a concept only when the responses that occur are "not situation bound". Gagné cites two fundamental differences between behaviours shaped by instrumental conditioning and those by conceptualizations:

(1) "Shaping an instrumental response is a matter of connecting the response with a specific "discriminative stimulus (. . .)
    On the other hand, conceptually mediated behaviour shows a very great generality with respect to stimuli . . ."

(2) „The shaped response is tied to a more or less immediately preceding stimulus, whereas concepts display the possibility of a delay, or an internal process . . ."

I think that the Skinner School has not carefully examined the problem of transfer of learning.

Further points which we will mention quickly are:

(1) The teaching machine dissociates thought and action. This is very important at kindergarten level and for the lower grades.

(2) Stressing too much the quantitative evaluation of learning seems dangerous. In education the evaluation of progress must also be qualitative.

(3) Skinner neglects the social aspect of learning. — How will children spending much time in individual booths learn to cooperate with others, to understand their point of view etc.

To put an end to this critical part, teaching with the Skinner system does not satisfy for many reasons: lack of deep motivation, questionable learning, etc.
But it is high time to say that I do not think that teaching machines of the Skinner group are useless. Like the machines of the Pressey type, Skinner machines can be of great help to teach dull or factual information. In other words, they are good *training machines*.

And all experienced teachers know that drill has its place in education and that the child, properly motivated, accepts drill activities without any difficulty.
In this respect the Skinner machine is a good instructional device among many other devices such as instructional cards, programed textbooks, instructional games, etc.

But if we look at it this way, the teaching machine is far from being the most important educational discovery of this century.

II. *The Adaptive Machines.*

The machines we have considered so far are rather naive. But in the era of huge computors and of translating machines one imagines easily that scientists have looked for devices that can reproduce more accurately the work that takes place in the human brain and also the interaction of pupil — teacher.

The first condition is a flexible program. As usual, the principle of flexibility or to use the technical term of "branching" is a very easy one. But to make this clear, I had better explain what a "Scrambled Book" is.

> "On the first page of such material the student finds the first piece of new information, and a multiple-choice question based on that piece of information. Each alternative answer to the question is preceded by a page number. The student picks what he believes is the right answer and turns to the page number given in front of the answer he has chosen. If he is correct, the page to which he thereby turns will contain the next unit of information and the next question. If he is incorrect, the page to which he has chosen to turn will contain material designed to correct the specific error he has committed, and will direct him to return to the original choice page to try again." (Western Design, 1955)

> Here is, for example, the first page of WESTERN DESIGN'S Instruction to computor number systems (abriged):

Page 1

We use a number system with ten different numerals: 0, 1, 2, 3 . . . 9. Each single numeral is called a digit. Because the system uses ten different numerals, it is called the d e c i m a l s y s t e m.

Question:

Are 492 and .29 both written in the decimal systems?

Answer.

"Yes" . . . . Turn to page 7

"Only .29 is written in the decimal system" Turn to page 13

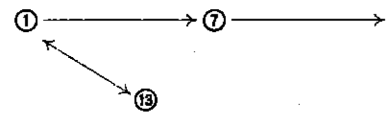
Page 7

You are correct.
(The next unit of information follows.)

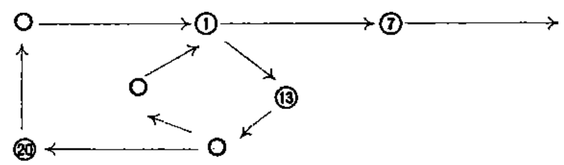
Page 13

(Explains why the answer is incorrect)
Return to page 1 and choose another answer.

The sequence we have just seen can be diagramed as follows:



The branching could be much more sophisticated. For instance, if I choose page 13 — that is the wrong answer — I can be sent on a remedial loop where I review what is necessary to understand the right answer. The diagram can be as follows:



In this example, branching is determined by errors. But other criteria can be used for branching: such as latency of response or the student's indication that he wishes to review or speed up. The best known machine following this principle is the "Western Design Tutor".

> Ii is an automatic random-access recording microfilm and motionpicture projector which cotains 1 000 or more motion-picture frames that can be presented in any order. By pushing a button on the control panel, the user sees a frame or a short segment of a motion-picture film. This material is followed by a multiple-choice question about it. As in a scrambled book, the student responds by turning to the frame numbered to correspond to the code number given by his answer choice. The great advantage of this scrambled book on film is that a complete record of the student's responses and of his latency is made. It can be analysed later on by the teacher.

All sorts of developments of this machine are possible. Tape recording, punched programs and even computors can be combined.

Finally the most sophisticated type of machine applies the operational game method. Fattu has described such a device used to train business executives to make decisions.

> "Data on the operating of a company such as one finds in a balance sheet are given to trainees. They are required to make various decisions relative to the operation of the concern. Each team's decision affects the outcome, so that a competitive situation is involved. Decisions are fed into an electronic computor that has been properly programmed. From these results, further decisions are made. Each cycle may represent a quarter of a year of operation." By this method it is possible to give several year's experience in decision making within a few months.

Pask proposed to use two machines IDMA (Interactive Decision Making Assembly) in conjunction: one of the machines represents for instance a population to which a product is to be sold and the other machine represents the businessman.

Of course, such an equipment is very expensive and not many schools can afford it. But proposed group-automated teaching devices have been already described by Bushnell and Silber: here many individual desks equipped with response keyboards are connected with a central computor with magnetic tape storage, light protector, etc. The computor would not only analyse the results of each student but also the behaviour of the class and select the material to be presented (E. Fry).

I think that the real future of teaching machines is here. They could be used by older adolescents and adults who have a definite purpose and are thus motivated. We can easily imagine how interested a medical student would be by a program training him for diagnosis.

Conclusion.

(1) My first conclusion is that it is too early to conclude. More experimentation is needed before we know whether the machine can be an efficient teacher or not.

(2) However, teaching machines can be considered as good tools for research. I think that the teaching machine movement will bring progress in two main fields:

   a) a better teaching — learning theory will probably be developed.

   b) our teaching methods will become more accurate.
   This benefit will result from programming research.
   To write a program for a machine, the teacher must re-consider each step of a lesson and gaps, shortcomings, etc. appear soon.

That is why the teaching machine has its place in each educational research centre.

(3) I personally have no doubt that more and more machines will be used to train adults and adolescents.

(4) Finally my general conclusion is that in this field as in all fields the educator must be very careful before he starts experimenting with children but that he must at the same time adopt a constructive attitude and study with enthusiasm any new development that can make education more efficient.

Diskussionsbeiträge zum Vortrag de Landsheere.

Ein deutscher Teilnehmer ergänzt zunächst aus seiner eigenen Arbeit an Lernmaschinen in Deutschland: Die USA sind Deutschland auf diesem Gebiet um Jahrzehnte voraus. Wichtiger als die Maschine ist das Programm. Bei richtiger Programmgestaltung ist die Maschine zu mehr als nur zur Dressur geeignet. Sie soll den Lehrer keinesfalls ersetzen, sondern nur unterstützen. Die in Deutschland entwickelte Maschine heißt „Repetitor" und wird vor allem in der Betriebswirtschaft, Technik und angewandten Mathematik eingesetzt. Mit ihr werden gute Ergebnisse erzielt. Eine größere Maschine mit Fragestreifen von 1500 Fragen ist projektiert. Sie soll sich allgemein in der Industrie, in Unfallgenossenschaften, Fahrschulen und in der privaten Weiterbildung bewähren. Sie ist nicht ursprünglich für die Benutzung in der Schule gedacht. Entwicklung und Programmierung sind sehr teuer. Darüber hinaus fehlt es an Lehrern für die Ausarbeitung der Programme. Die Lehrer Höherer Schulen sollten sich aufgerufen fühlen, an dieser Aufgabe mitzuarbeiten. Denn das Bildungsbedürfnis ist sehr groß, und die Maschine vermag es zu befriedigen.

Einige Teilnehmer ergänzen: In den USA wurde bisher sehr viel Geld für die Forschung auf dem Gebiet der Lernmaschinen aufgebracht. Die Luftwaffe der USA z. B. arbeitet mit ihnen und hat seitdem bessere Lernergebnisse erzielt. Auch die Berliner Volkshochschule verwendet Lernmaschinen mit Erfolg. Die Maschine kommt darüber hinaus allen denen entgegen, die das Bedürfnis haben, für sich allein zu lernen.

Die Diskussion beschäftigt sich dann mit der Frage, ob die Maschine sich für die schulische Arbeit eignet. Auf den Einwand eines Teilnehmers, die Isolierung eines Kindes mit der Maschine in einer Lernkabine sei jugendpsychologisch bedenklich, erwidert der Referent: In den USA arbeiten Kinder nur während eines kurzen Teils des Tages unter den genannten Bedingungen. Deren jugendpsychologische Wirkungen sind — im Gegensatz zur Frage der Lernerfolge und der Wirkung für die Wiederholung — noch nicht erforscht. Doch dürfte die Isolierung für so kurze Zeit ungefährlich sein. Sie ist sogar, ergänzt der Diskussionsleiter, mit Maßen gehandhabt pädagogisch positiv zu beurteilen.

Auch andere Teilnehmer heben vor allem den mit der Maschine verbundenen Gewinn hervor: Die Maschine eignet sich für häusliche Aufgaben, besonders für Wiederholungen und zusammenfassende Übersichten. Kranke und krank gewesene Kinder können vor allem mit ihr arbeiten. Ihr pädagogischer Wert liegt darin, daß sie von der Strafdrohung befreit. Auch Gruppen können mit mehreren Maschinen zugleich arbeiten. Dabei kann sogar das Spiel zu seinem Recht kommen. Die Maschine braucht also keineswegs schockierend zu wirken. Sie steht in Analogie zum Buch.

Natürlich begegnen besonders die Lehrer (nicht nur in Deutschland) der Maschine zunächst mit Zurückhaltung. Es gibt jedoch genug Gründe, aus denen sie der zukünftigen Entwicklung mit Ruhe entgegensehen können. Sie sollten bei ihrem Einwand gegen die „Unnatur" der Maschine nicht vergessen, daß auch in der Erziehung gelegentlich „Unnatürliches" getan und angestrebt wird.

Einige Teilnehmer betonen auch die Grenze der Maschine: Sie kann keine Erziehungsarbeit leisten.

Noch ungeklärt ist die Frage, ob die rascher erworbenen Kenntnisse und die verbesserten Prüfungsergebnisse, die etwa in den USA mit Hilfe der Maschine erreicht wurden, auch zu gesteigerten praktischen Fähigkeiten führen.

Der Diskussionsleiter faßt zusammen und ergänzt: Statt in Reserve oder Resignation zu verharren, sollte der Lehrer erwägen, was ihm mit der Lernmaschine zur Verfügung steht. Er wird zu dem Ergebnis gelangen, daß er sich ganz auf die ihm vorbehaltenen Aufgaben konzentrieren kann, weil er vom Unwesentlichen entlastet wird. Die Maschine muß nicht in der Lernkabine, sie kann auch im Klassenraum benutzt werden. Selbstarbeit sollte mit Gruppenarbeit (an der Maschine oder im Unterricht) wechseln. Wenn das Kind mit der Maschine allein ist, kann es in seinem Tempo arbeiten. Zeitraffung und Zeitgewinn werden wohl in jedem Fall Früchte der Arbeit mit der Lernmaschine sein.

Der Referent mahnt am Schluß noch einmal zu Nüchternheit und Sachlichkeit bei der Begegnung mit dem Neuen, in diesem Falle der Maschine. Unter ihrem Einfluß wird die Aufgabe entstehen, die Organisation der Schule und des Unterrichts neu zu überdenken und eventuell zu verändern. Neu werden dabei Amt und Aufgabe des Programmgestalters sein.