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Programmed Learning and its Application in the Classroom

Summary of a lecture

by

L. G. W. Sealey

PROGRAMMED learing has been treated seriously in the U.S.A. since 1957 and in the United Kingdom work has been going on since 1959. Although I have been concerned personally with programmed learning in both these countries, I do not wish you to think in any way that I am an expert. I am not even sure that experts exist. There is of course a great deal of programmed learning going on in our schools in Leicestershire and I can think of one school particularly where there might be as many as a hundred devices to assist in this field, so I suppose it could be said that on the practical side, I have had a fair amount of experience.

First I must make it clear that we have to be rather careful of our terms. If we talk about programmed learning, we are meaning one thing and if we talk about teaching machines, then we might be talking about something a little different. Programmed learning is really what it says. It is a careful consideration of what has to be learnt and the description in explicit terms of the path towards such learning. If you look at programmed learning from this point of view, then most of the efficient class teaching may occasionally be programmed learning. In other words, if you carefully describe the goals and map out in detail with reference to the children who are to learn a carefully described path, then you have indeed programmed the learning. But programmed learning has come to be associated with the preparation of a path to the learning of something without the intervention of the teacher. As you will see later on, I am not sure whether this is not a rather false and stupid point of view to take. As I become more experienced in the application of machinery and cybernetic devices to programmed learning, I come more and more to the point of view that ultimately, when you have this thing completely in perspective, we shall include the teacher rather than exclude him. In fact, some of the most recent work that I have been doing actually programmes the teacher's contribution into the path. It describes exactly at certain points in this path where the teacher must be consulted.

Programmed learning started off I suppose, with Dr. Edward L. Thorndyke when he wrote in 1912, "If by a miracle of mechanical ingenuity a book could be so arranged that only to him who had done what was directed on page one would page two become visible and so on, much that now requires personal instruction could be managed by print". This is really inherent in programming. You have a goal — usually some fine piece of knowledge or factual information if you wish — and you have a learner and you see to it that he proceeds directly to the knowledge using the ideal path and you don't allow him to go from the first step to the second step until the first step has in fact been taken correctly.

There are three other names that ought to be known to you because these three people have considered the problem from different points of view and have come to rather different conclusions.

The first of these is Dr. Skinner, who was Professor of Psychology at Harvard University. He has been responsible for what is known as linear programming. Do not confuse this with the branch of mathematics called linear programming. That is an entirely different field. Skinner's linear programme stipulates that you have an ideal path which is linear, where the steps are hierarchical — one must come after the other — and you just proceed along these steps until you reach the knowledge and once you have in fact followed the path, then the knowledge has been assimilated. You break up the knowledge that has to be learned into appropriate small parts and you acquire them hierarchically along the way. Skinner came to this idea as a result of consideration of the behaviour of Norwegian pigeons. Some people laugh at this, but nevertheless, Skinner is a very careful experimental psychologist and his work is impeccable from several points of view. Not everybody agrees with the philosophic basis, or even with his psychological thesis, but what Skinner has done, he has done impeccably. His work is elegant, thorough and extensive.

The second person whose name must be known to you is Norman Crowder. He was a psychologist at the University of Chicago and during the war, went into the United States Army Air Force. There he met various problems that young men in training

came up against in regard to learning and he devised a sequential kind of learning, which has become known as branching or intrinsic programming.

In the linear programme the steps are very small because programmes are designed in such a way that at least 95 per cent of all learners are able to cope with their difficulty. They require no complicated machinery and the simplest idea is to have a sort of box where the material is printed on rolled paper or sheets of paper to follow one after the other and you expose a part of this only and this is your stimulus. Next to it is the correct answer to the previous step. You advance by means of a roller, each time you look at the stimulus, think about it and do whatever is asked. You make your response actively by means of a pencil, you turn the knob forward and you can't turn it back. The whole basis of the psychology of learning which Skinner uses is that you have a stimulus, you make an active or constructive response and then the response is reinforced. You are indeed reinforced with the knowledge that your response has been correct, as it almost certainly will be because these steps are very, very small.

Can you see some objections to this linear programme? The first is that it is extraordinarily tedious. If 95 per cent of all people must in fact construct the correct response, then the steps are going to be very small indeed. In a programme concerned perhaps with simple algebraic relationships, you may have as many as 2,000 of these frames and the very bright child is supposed to go fast through the programme, but it is quite tedious for very intelligent children to take these little tiny steps. On the other hand, in branching or intrinsic programming, the learner takes much bigger bites at the cherry and for bright children this is far more satisfying, but of course it has a disadvantage in that, if these steps are large ones, then the things you have to deal with are also going to be large and very bright children can often not be bothered to go through all the words and diagrams that make up the stimuli. They almost get the idea and tend to not look at it carefully enough.

In a branching programme, as I say, the size of the steps from one piece of knowledge to another is much larger and they are usually designed so that only five per cent of the students will go by means of these giant steps towards the goal of their learning. The others who make an error on the main frame are directed sideways to other frames designed to correct their errors and only when this has been done do they return to the main path. Quite obviously the kind of device needed to have this degree of sophistication is very much more complex than the kind of device needed for a linear programme. An example of this is the Auto Tutor, a kind of electrically operated rear projector with a tremendously long film strip put on a reel which is projected from the rear onto a ground glass screen. The stimulus is considerable and there are a number of buttons for the student to press. He reads through the stimulus, thinks about it, perhaps carries out some action and having done so, selects the response. If you think the response is B, you press button B and if you are correct, you advance to the next main step. If you are not correct, you are sent sideways to what is really a remedial frame, which goes over the matter in further depth, adds in some new information and returns you to where you were before, so that you may try to understand this main stream frame again and hopefully select the right response.

If you are a slow learner, your progress may therefore be sideways and back, sideways and back, to the capacity of the machine. Of course, the capacity of the machine and the size of the steps and the information contained in these frames is very carefully blended to take up the variations in the learning ability and the achievement levels of the pupils.

The third kind of programmed learning involves a third kind of teaching machine and arises from a difficulty that is common to both the two I have already mentioned. When you are engaged in a tutorial relationship with a pupil, what do you do? Imagine that you are in a one to one correspondence with your pupil. What do you in fact do? First of all, you have clear in your own mind the field of discourse. You decide what you are going to talk about. Then you initiate the conversation. You start and by means of question, exposition, illustration, experiment, you get the student to react. In other words, you provide a variety of stimuli and you get the response. As a result of that response, you modify or adapt and what comes next depends upon the feedback that you have had. Now the kind of machine or device which will be adaptive, which will modify the next stimulus as a result of the feedback from the pupil is that branch of programming called adaptive programming and this is the work of Gordon Pask, a young Englishman, still under 40, who is so far ahead of the rest of the mere mortals that an evening with him is an indescribably painful experience. I visited him in his London flat two years ago to see a new thinking machine that he had been working on which was not electronically based, but chemically based. After all, electronics are better than mechanics, but chemistry is better than electronics and he had been working on some new, secret, chemically-based thinking machine and I was terribly impressed by his work. He said, and this frightened the life out of me, that if I was prepared to spend six months with the machine and if I was prepared

to answer problems in front of the machine, then in six months time, the machine would take over from me and would answer problems rather better than I could. The reason being of course, that the thinking machine has an infinite capacity memory. It never forgot anything. All my operations and styles would be assimilated by the machine and before very long, the machine would be more efficient. It could not create anything, but it could certainly assimilate and adapt in a ruthlessly efficient way.

So we have these three kinds of programming, a linear, branching and adaptive. Notice that the adaptive work as a result of feedback and the science of cybernetics is the science of feedback. It was pointed out rather jocularly some years ago that here we are using all our energies and time and money and effort to get truly adaptive machinery, when in fact we have such devices available already and they are called TEACHERS. I think it is worth repeating that we must not get caught up in this jungle without realising what we are doing. If you could, when necessary, as an adaptive device par excellence, come into one to one correspondence with a child when he or she needs it, then you would not need a multi-million dollar cybernetic adaptive device which can never be as efficient as you—we hope. We hope, but are not sure, because there are differences. None of these devices ever gets tired or needs coffee, or lunch. They are ruthless and efficient. They never tire. They can work all day and all night as long as you feed them with energy of some kind—electrical energy, mechanical energy, or some other sort of energy.

I should like you to look at an assumption made about programmed learning before we go any further and get carried away with the delights of this 1984 kind of situation. This is the assumption that human beings can be so blinkered that they learn only one thing at any one time. In order to prepare a programme, a number of assumptions are made, but the basic assumption is that if the frame or stimulus is right, then the child will learn only what is inherent in the stimulus. I was thinking about this recently and I came across some work of Jules Henry, who is an anthropologist. He said that we must never forget "the inordinate capacity of a human being to learn more than one thing at a time". In other words, it is really in the nature of Man that he does not learn one thing at a time. He learns many things at a time. His whole being is available, his antennae picking up all sorts of things and therefore, when we transmit the message to him in this linear form, or branching form, or any other form, what message apart from the one we are transmitting, is in fact being picked up? He may be learning first of all that somebody has anticipated every aspect of every problem and there is nothing original for him to do. That bothers me very much because we are looking for people who can ask questions, who can find new slants to problems; who can see new problems and not just deal with little bits of problems or solve even rather complex ones. We must have people who can ask new questions and raise new problems. That is what is essential to our future development. And the other dreadful thing is that the child who follows this kind of path all the time will almost certainly learn, although it is not built into the philosophy, that every question has an answer and that it is possible to say whether the answer is right or wrong. Now every question does not have an answer. And is it not possible to say whether every answer is right or wrong? I do not want to become a Norwegian pigeon. I want to maintain my individuality and I think we must realise that if ever we bring this kind of thing into the classroom, we may be teaching something about which we do not know.

How about construction of the actual programme? Somebody yesterday asked me about a certain teaching machine and I told him that it was quite a reasonable and cheap one, but I said it has not got any programmes and he said, "Well, I am not too worried about that; we can write our own." But writing your own programme is not the simple business that it seems. You don't just write a few things on a piece of paper and hope for the best. You have got to realise that the programme is of no use if it does not in fact teach. It has to teach 95 out of every 100 students. Therefore, it has to be validated. The production of programmes is a lengthy, expensive and difficult task, requiring not only knowledge and imagination, but patience and revision.

What about the work in schools? When would you use a programme of the linear type? Would it be better to use a programme of the branching type? Would it be better to get some of this adaptive machinery into the classroom? I can't answer these questions for you, but I can give you some general, personal points of view. You will remember that when I was talking about science, I said that we had a sort of playing-about stage and then a stage when you were more specific. There was a stage when you tried things out and then a stage when you generalised about them. Now programming has nothing to do with the first stage, but it may have something to do with the second stage, when you are exploring one particular point of view or idea or piece of learning. Short linear programmes of 200 or 300 frames are very good for this, but they are no substitute for the experimental stage or for the real experience. We have been using linear sequences with machines, without machines or just in books for a long time and they are very effective when:

(*a*) the child is motivated to learn whatever the programme is about, and

(*b*) when the sequence is short.

It is no good setting a young child off on a linear sequence which is going to take him two months. In my experience young children just become extremely bored. I do not think branching programmes are very much better than linear ones within the context that I have described and I do not think there is any need to worry about adaptive programmes. I think the main point to realise is that before you start on a programme, you have got to be motivated to learn what there is involved.

Let me tell you very quickly several of the more exciting things that we have been doing in our schools in connection with programmed learning. One of the real problems is to deal with the slow reader, the child who fails to learn to read by conventional methods. During this past year, one headmaster has been working on this problem and has largely overcome it by a very nice and sophisticated device. It consists of a box, which has on it a little speaker and a switch and a slot. A series of cards is prepared which have printed on them the various symbols, either ITA or traditional orthography, which represent a meaningful phrase, e.g. "The boy is out shopping" and there would be a picture of a boy in the High Street, but the card also has on it a prepared magnetic tape, so we have a picture, some unintelligible symbols and a magnetic piece of tape. The child has the cards in a sequence and incidentally six months work went into the preparation of the sequence of cards, which is the programme. The cards are slipped into the slot of the machine and the pupil presses a lever. When he does so, the child hears the words spoken by the teacher, "The boy is out shopping." The child then takes the card out of the machine, pops it back, switches the lever the other way and reads out the words himself. He then listens to himself, takes the card out again and again listens to the teacher. If he has made a mistake, he does his part over again and it automatically erases the previous attempt. It is really very simple to operate and reasonably unintelligent children can handle this because they are used to handling all sorts of similar machinery.

That of course is not the whole of the programme. There are three further stages towards putting right reading which has failed. In the first stage, the child sits with a head set on his ears and listens to a tape which has been pre-recorded in which the teacher reading the story introduces him to words and sounds within a meaningful context, which he sees in a book in front of him. The teacher draws attention to the words as they go along. The child can stop the tape or listen to it as many times as he likes and he has the words in front of him in a traditional book. In fact, as many as six children can sit round the tape recorder, each listening to their own head sets. The tape may say something like this. "Now you are going to learn to read. In front of you, you will find six little books. Give them out and see that you have them the right way up. The top of the book has a big red stripe across it." Then there is a pause. The children give the books out. "Now you have all got a book. Good. That is fine." This is the way the tape reads because you are simulating a tutorial relationship. "Now books have pages and we are going to turn over the first page. So open the book at the first page. You can tell it is page 1, because there is a numeral at the bottom. Put your finger on the numeral 1. That's right. Good. You have got your finger on the right place. Just look round and see that everybody has their finger on the same spot." No teacher. Just the machine. "Now I am going to read this story to you. You have heard lots of stories before and you have seen lots of books. This is a special book written specially for you. Put your finger on the first word. Do you know what a word is? Yes, that's right. Good. The first word. Now I am just going to read the story to you and I want you to run your finger along the words that I read. I shall read very slowly." Then the teacher reads and the voice says, "Where am I up to now? Have a look round and see that you are all pointing your finger at the same spot."

And so it goes on. After that we come to the analytic stage. In the first stage, the teacher is in control. Notice that this is programmed learning. The teacher is in control by means of the inanimate tape. Who is in control in the second stage? Well the child thinks he is, but he isn't really because the teacher has pre-programmed the work. The third stage is the confirmation stage. The child goes back to the teacher with the book and can read it. Every word can be read. Reading the book is the confirmation of the learning. If the child can't read the book the teacher says, "I think we had better go back to the cards, but instead of starting at card one, I think you ought to start at card seven and work through the rest of the sequence." I am quite sincere when I say that we have largely overcome reading problems with children of 9 to 10 with this very, very new work and with this very simple device. I am sure you can see the possibilities of using this machine for all sorts of other things. It is a very flexible new piece of armament in our attack on the educational problem.

Some of the other interesting work has been the amalgam of a linear programme in book form. All you then really need is to rule off the page so that the stimuli appear on the one side and the response on the other side of the page with the response to

stimulus A alongside stimulus B. You provide a mask which is simply a piece of cardboard which the child moves by himself. He can write his answer on an ordinary sheet of paper or in an excercise book. All this business about children not cheating or not turning back, which is inherent in the more formal teaching machine, I have found to be absolute nonsense. It is quite unnecessary and cheating has nothing to do with this game at all. Sometimes, because the programme is not very good, the children must look back, but if you say to them, "Don't alter your answers because I am trying to see whether you are learning from this," they won't do so. This sort of sequence can be used in conjunction with an automatic slide projector with a remote control and if you have a screen and some picture and say a box of material that you need, you can now produce what I think is the answer to programming for junior children. A group approach to learning. You can have a group of children working together using the automatic slide projector, all of which is built into the programme. The programme will say, "Now select slide one." The child just presses the button and the stimulus is there. He has the visual stimulus, actual, real material with which he can experiment and the written programme. If you are clever, you can write the programme so that it not only helps the children to learn and to resolve answers to specific problems, but also raises new questions.

To conclude, I should like to say that already in Leicestershire, we are building into our new schools, limited facilities for this kind of work. I think that in a group of say 80 children, at any moment of time, 12 or so of them will be working individually with programmes. We are developing in our libraries resources of this kind, stacks of slides for automatic slide projectors, series of programmes and pre-programmed tapes. These things do a very good job in two ways. First, if they are properly produced, children really do learn and secondly, you can hive off even in your classes of 20, a group of 5 or so children and know that they are being taught more efficiently than you can do it in an ad hoc way. You see, if you take one of the American linear programmes on, say, modern algebra, then this has been prepared at the cost of several thousands of dollars, has been validated by thousands of children and has been produced by people who know their jobs, both psychologists and mathematicians and it is probably a darn sight better than you can do at the drop of a hat with a piece of chalk and a blackboard. Programming properly used is a very important aid to us in our educational work. I am sure it is here to stay and we must not turn up our noses at it.

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