Learning by Doing through Programmed Instruction
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Learning by Doing through PROGRAMMED INSTRUCTION

Programmed instruction can be compared with the tutorial method of teaching in which there is an exchange between the tutor and his student and a constant introduction of new material as the student masters the previous material.

But, in programmed instruction there need not be a teacher. The exchange usually takes place between the learner and the material which is arranged in steps of gradually increasing complexity—each one boxed in a "frame"—so that the learner can easily proceed from what he knows to new and more complex materials. Each learner's response and his rate of progress is an individual affair; his responses are not conditioned or determined by the responses of others.

Programmed instruction has been used in elementary schools, high schools, nursing schools, colleges, and in industry. It has proved to be adaptable for various kinds of adult education. It is a teaching technique which holds great promise for the future–a technique which seems to be particularly useful for continuing education. This article describes programmed instruction, gives several examples—one in physiology —and indicates some of its uses.

FRANCIS MECHNER

The application of behavioral science to various problems in education has resulted in some startling innovations. One of these is the self-teaching technique called programmed instruction. Through specially designed programmed texts, physicians are keeping up with new developments in medicine; unskilled industrial personnel are learning how to operate complex equipment; trigonometry students are learning to do logarithms; illiterates are being taught to read and write; and detail men are learning to explain the chemical structure and clinical use of new drugs.

Basically, programmed instruction involves the application of theories of learning to practical problems of education. Thorndike at Columbia and Watson at Johns Hopkins first suggested that the findings of experimental psychologists should be applied to educational practice; Hull at Yale formulated a theory of concept formation in 1920 which proved to be extremely important, but it was Skinner at Harvard who laid most of the scientific groundwork for the development of behavioral technology. The past five years have seen a remarkable burgeoning of interest in this new technology, and the use of programmed instruction in a wide variety of fields has resulted in more rapid and more complete learning than was achieved by other methods of instruction, often with difficult, technical material.

As the technology of programmed instruction evolved and matured, a variety of methods and techniques have developed. Obviously, postgraduate medical education programs will look very different from programs designed for elementary school children, and both of these will look different from programs designed to teach people how to listen more effectively. However, they all have certain characteristics in common.

A very simple example follows. By doing the items at the top of the next page, you can teach yourself, in about two minutes, how to square, mentally, any number ending in five. Be sure you always write in your own answer before looking at the correct answer, shown in the right hand column. Cover the correct answer with a piece of paper until you have written in your own answer.

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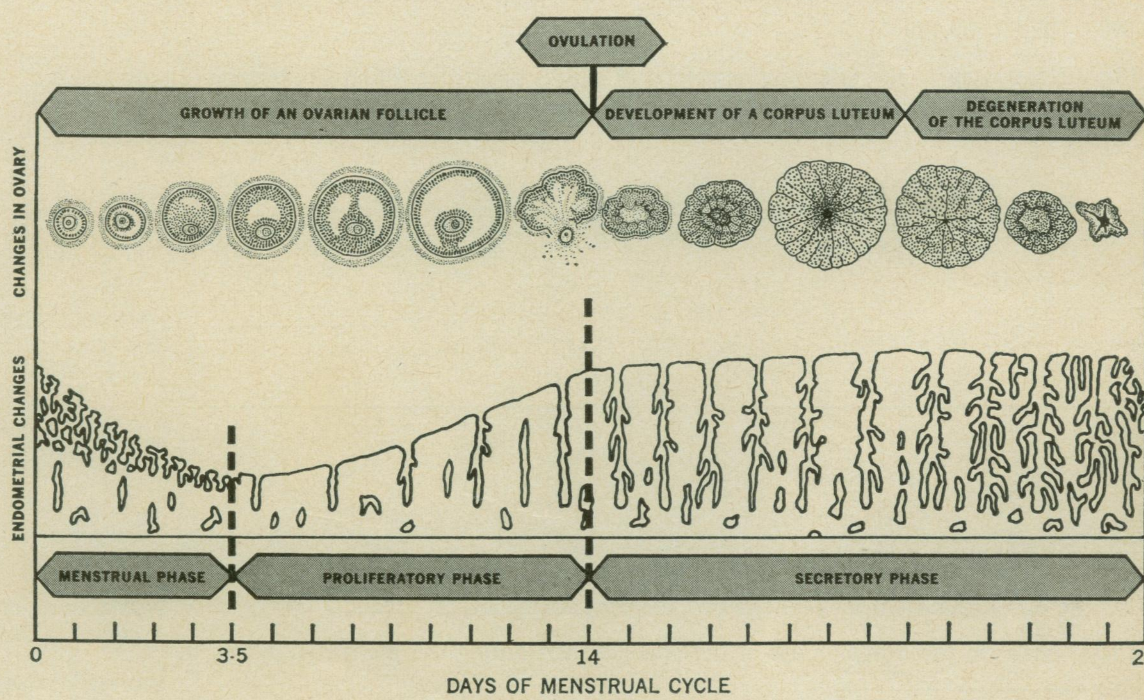
QUESTIONS	ANSWERS
1. Here is how you can square 15: 15 lies between 10 and 20 10 × 20 =_____ 200 + 25 =_____	 200 225
2. Here is how you square 35: 35 lies between 30 and_____ 30 × 40 =_____ 1200 + 25 =_____	 40 1200 1225
3. Here is how you square 65: 65 lies between_____ and_____ _____× 70 =_____ _____+ 25 =_____	 60 and 70 60 × 70 = 4200 4200 + 25 = 4225

QUESTIONS	ANSWERS
4. Here is how you square 45: 45 lies between . . . _____×_____=_____ _____+_____=_____	 40 × 50 = 2000 2000 + 25 = 2025
5. Here is how you square 25: 25 lies between . . . _____×_____=_____ Finish the example, mentally:_____	 20 × 30 = 600 (600 + 25) 625
6. Here is how you square 75: 75 lies between . . . _______________	 (70 × 80 = 5600 5600 + 25) = 5625
7. Square 55, mentally._____	3025
8. Square 85, mentally.	7225

Another example of programmed instruction are the following excerpts from an already published program. Panel 3 (below) is referred to in the frames on the next two pages.

PANEL 3

Ovarian and Endometrial Activity During the Menstrual Cycle



5

TURN TO PANEL 3

Panel 3 depicts the sequence of events in the ovary and endometrium during the menstrual cycle.

What structure is present in the ovary:

following ovulation? ____________ — corpus luteum

prior to ovulation? ____________ — (ovarian) follicle

What is the phase of endometrial development:

during the menses? ____________ — menstrual phase

following ovulation? ____________ — secretory phase

immediately prior to ovulation? ____________ — proliferatory phase

What is the phase of endometrial development when a fertilized ovum could be present for implantation? ____________ — secretory phase

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6

REFER TO PANEL 3

As the panel indicates, development of a corpus luteum within the ovary is followed by ____________. — degeneration of the corpus luteum

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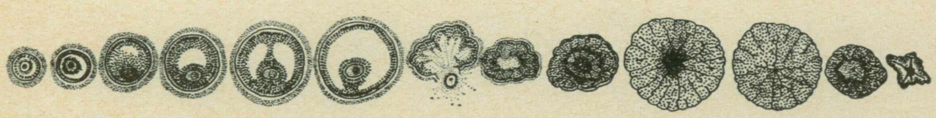
7

DO NOT REFER TO PANEL 3

LABEL the last step of the following sequence of events occurring within the ovary during the menstrual cycle:



GROWTH OF AN OVARIAN FOLLICLE → OVULATION → DEVELOPMENT OF A CORPUS LUTEUM → ____________

→ DEGENERATION OF THE CORPUS LUTEUM

8

REFER TO PANEL 3

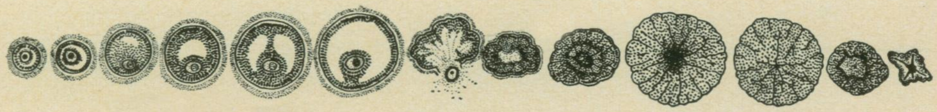
Within the ovary, the event that follows ovulation is ____________. — development of a corpus luteum

The final phase in the development of the endometrium during the menstrual cycle is the ____________. — secretory phase

9

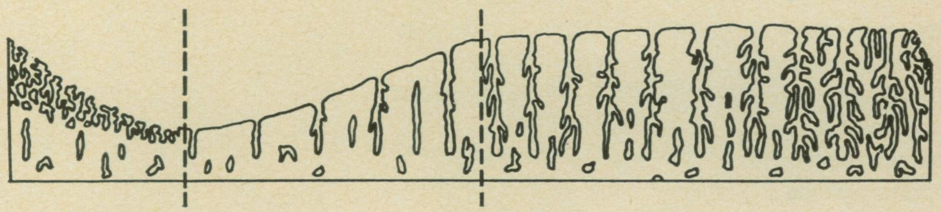
DO NOT REFER TO PANEL 3

LABEL the missing steps in the following diagrams to indicate the sequence of events within the ovary and in the endometrium:



GROWTH OF AN OVARIAN FOLLICLE → OVULATION → ______________ → ______________

→ DEVELOPMENT OF A CORPUS LUTEUM → DEGENERATION OF THE CORPUS LUTEUM



MENSTRUAL PHASE → PROLIFERATORY PHASE → ______________

→ SECRETORY PHASE

10

REFER TO PANEL 3

What event within the ovary follows growth of an ovarian follicle? ______________

ovulation

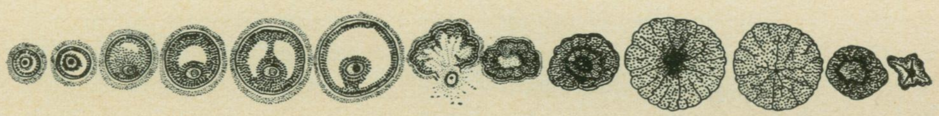
In the endometrium, the phase that follows the menstrual phase is the ______________.

proliferatory phase

11

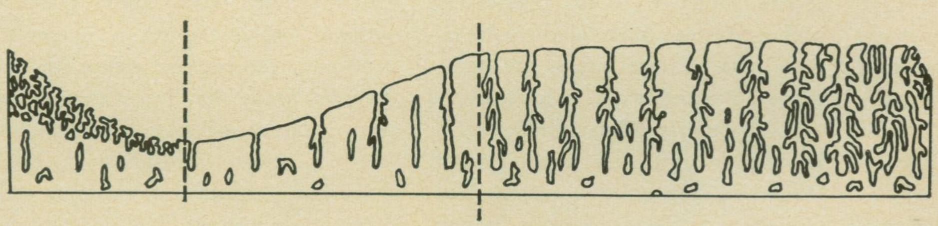
DO NOT REFER TO PANEL 3

LABEL the missing steps in the following diagrams to indicate the sequence of events within the ovary and in the endometrium:



GROWTH OF AN OVARIAN FOLLICLE → ________ → ______________ → ______________

→ OVULATION → DEVELOPMENT OF A CORPUS LUTEUM → DEGENERATION OF THE CORPUS LUTEUM



MENSTRUAL PHASE → ______________ → ______________

→ PROLIFERATORY PHASE → SECRETORY PHASE

When the learner has completed the above frames and frames 12 through 21 (not included with these excerpts), he should be able to complete correctly test frames 22 and 23, shown on the next page.

22 CHECK the phase(s) through which the endometrium passes while the corpus luteum is present in the ovary: ☐ the menstrual phase ☐ the proliferatory phase ☐ the secretory phase	the secretory phase

23

MATCH each of the following stages of ovarian activity with the phase(s) of the endometrium that correspond(s) to it in time:

A. onset of menstrual phase
B. during menstrual phase
C. end of menstrual phase
D. onset of proliferatory phase
E. during proliferatory phase
F. end of proliferatory phase
G. onset of secretory phase
H. during secretory phase
I. end of secretory phase

	Answer
1. ______ degeneration of corpus luteum	1. I
2. ______ follicle reaches maturity	2. F
3. ______ onset of follicle growth	3. A
4. ______ onset of growth of corpus luteum	4. G
5. ______ ovulation	5. F, G
6. ______ period during which corpus luteum is present	6. G, H, I
7. ______ period of follicle growth	7. A, B, C, D, E, F

As can be seen from these examples, the main features of programmed instruction are:

1. Step-by-step progression in complexity of material. Each step is a question or problem to which the student must make an active response before he can proceed. Because each step builds upon the knowledge taught in the previous steps, the student is never required to answer a question about a subject until he has learned the answer to it.

2. At each learning step, the student is required to make an active response. He is not the passive recipient of information; rather, he exercises and practices his knowledge and skill as he acquires it. He "learns by doing."

3. As soon as the student has made his response to an item, he can find the correct answer which is normally shown alongside the question. In this way the student is reassured that he is progressing satisfactorily.

Different learners will progress through a program at different rates. In a group of thirty, the fastest learner may progress three times as fast as the slowest learner. With programmed instruction, the fast learner is not held back by the slow one, and the slow learner is not left behind in a state of helplessness and confusion. Also, learners who might be embarrassed to demonstrate their ignorance or show their failure to understand in front of other persons can be "stupid" in private. When he is taking a program, a learner can go at his own pace and make "silly" mistakes without anyone else knowing about it.

The variety of programming methods and techniques currently in use are due to the varying requirements of different types of subject matter as well as to the differences in learner groups. Programs intended for children in the lower grades use shorter frames and smaller step sizes than those intended for children in higher grades. Programs in advanced areas, such as post graduate medical education, have frames which are sometimes an entire page in length, and which assume considerable prior knowledge on the part of the learner. When the learner group is particularly heterogeneous, various branching devices, such as express stops, may be used. An express stop is a self-diagnostic frame, in which the learner is told that if he is able to answer a particular question, he may skip ahead to a specified point, but if he is unable to answer it, he should proceed to the next frame. This is just one of several devices used to accommodate individual differences.

Not all programmed instruction uses the paper-and-pencil response mode. The response mode must always be related to the type of behavior being taught. For example, if the behavior to be learned is a conversational skill, then the program must require spoken responses. If the behavior to be learned is typing, then the responses must be made on a typewriter. Some programs in industry use the audio-lingual mode to teach interpersonal skills, such as interview skills. In an audio-lingual program, the learner hears his instructions and hears sample conversational exchanges on a magnetic tape or a record. He makes his responses orally, or by selecting an answer from several possible answers in a special response booklet.

In the early days of programmed instruction, a great deal of attention was focused on teaching machines. A teaching machine is primarily a device which exposes only one frame of the program to the learner at a time. When the learner has responded, he then is able to advance to the next frame by pushing a knob or button. The main advantage of a teaching machine is that it prevents "cheating"—peeking at the answer before having made the response—and unauthorized looking back at previous frames. But, machines are expensive, can break down, are difficult to move or carry around, tend to slow down the student, and restrict the range of programming techniques that can be used. The trend in the past few years has been away from teaching machines and toward programmed text presentations, illustrated by the samples in this article. When the technical problems are solved and when costs are reduced, it is quite possible that this trend will be reversed, but this is not likely in the very near future.

Although programmed instruction has not yet achieved the same degree of success in the school system that it has achieved in postgraduate education and in industrial training, there is every indication that it will eventually be used to a greater extent in the classroom, especially if good programs become available, and teachers learn to select and use them.

There is certainly no lack of interest in this new technology among teachers. With some, this interest arouses hope and expectation; with others, anxiety. Some teachers have voiced the fear that they may be replaced by programmed instruction, this fear is quite unjustified. Some teachers have assigned programmed instruction as homework. Other teachers have used programs to help the class learn the basic subject matter, and then have used the remaining classroom time for discussion, questions, and exchange of ideas. It has frequently been said that programmed instruction can take much of the drudgery out of teaching: grading homework is eliminated because programs do not need to be graded. Tests and examinations become comparatively less important, because students who have completed a program can be counted on to have achieved the required levels of knowledge. Professionally developed programs usually will produce median final examination scores of 90 percent, or better. Only those students who have not taken the program can fail the final examination.

PRODUCING A PROGRAM

As in any other technology, the production of effective materials requires the collaboration of a team of specialists.

Before a program can be prepared, the behavioral changes that the program is expected to produce must be described in detail. Programmers do not talk about what the learner should "understand" or "know" or "be familiar with." They talk about what the learner should be able *to do* after having completed the course that he could not do before: the questions he should be able to answer, the problems he should be able to solve, the explanations he should be able to give, the diagrams he should be able to draw, and the kinds of responses he should be able to make in given situations. These are all examples of behavior. Once the behavioral outcomes are known, production of the program can begin.

The initial step in the production process is called "task analysis." This is the identification and description of the tasks which the student must learn to perform in order to do his job or carry out the objective established for the program.

Task analysis requires the collaboration of subject matter experts and behavioral psychologists. The subject matter experts must be familiar with the problems of the occupation for which the learner is being trained, and must be able to identify the individual tasks that must be learned. The psychologist (or "behavioral technologist") then insures that the description of these tasks is specific, operational, and behavioral. He must be sure that the tasks are specified in terms of the situations that arise in practice, and in terms of the responses which the learner is expected to make in these situations.

The task analysis approach to planning the teaching of subject matter will yield a syllabus which will be different from that which other approaches might yield. For example, if one approached the development of a syllabus for a nursing course with such questions as, "What topics should a nurse study?" or "How much physiology does a nurse need to know?", the syllabus would be different from one developed by asking, "What are the situations and problems which a nurse encounters and how should she cope with them?" This latter approach is the one taken by the behavioral technologist in carrying out a task analysis. However, this does not mean that theoretical background knowledge is neglected. When the behavioral technologist analyzes the decisions and judgments a nurse must make in order to cope successfully with any particular situation, he quickly discovers that the nurse needs theoretical background knowledge although many of the skills she uses are practical ones. The behavioral technologist carrying out a task analysis works back from the tasks, which he and the subject matter expert have identified, to the background material which must be mastered in order to enable the nurse to cope with the tasks successfully.

One significant finding in a series of task analyses carried out in nursing is that among the nurse's most critical skills are those of an interpersonal nature. The nurse spends more time with the hospitalized patient than any other professional worker, and the patient often develops an emotional as well as physical dependence upon her. To some extent, the nurse assumes some of the functions normally fulfilled by the patient's family. It is not enough to say that a nurse must have sensitivity, understanding, perception and the ability to use herself in her interaction with the patient. These are skills that she can acquire systematically. In programmed instruction it is the task analyst's responsibility to work with the subject matter expert to identify, define, and analyze the specific behavior needed by a nurse in given situations so that she may then be taught some of the necessary interpersonal skills.

Once the task analysis has been completed, we know in general what should be taught in the course. The next step is to describe these tasks in such a way that we can use the descriptions, known as specifications, as a test of whether or not a learner has acquired the desired knowledge when he has completed the program being developed. The emphasis is upon behavior and the conditions under which this behavior is to occur. The questions the learner should be able to answer, the problems he should be able to solve, and the situations with which he should be able to cope after having completed the course become the specifications of behavioral objectives. Examples of specifications of behavioral objectives are frame 7 on page 100, and frames 22 and 23 on page 102.

Next, the behavioral technologist examines these objectives and dissects them into their most minute behavioral components. He breaks them down into categories and classifications that make sense from a teaching standpoint. The behavioral technologist works in collaboration with the subject matter experts. He needs the answers to detailed, specific questions from someone who knows the subject matter thoroughly. He may ask such questions as "What are some examples of concept X?" "Will the student confuse concept X with another superficially similar concept?" By asking questions of this type the behavioral technologist obtains lists of examples and "non-examples," which can later be used in the concept formation process. When the learner later learns that a, b, c, and d are all examples of concept X, and that e, f, g, and h, though they look like cases of X, are not cases of X at all (non-examples), but rather cases of Y, the psychologist says that the student is learning the concepts X and Y. During the process of analyzing the desired behavior, the behavioral technologist also asks such questions as "What is the first question the student should ask himself when confronted with problem Z?", and "What are the detailed steps of the reasoning process which the student should follow when trying to solve Z?" The term "problem" is used here in a broad sense; it could be an interpersonal situation, a clinical situation, or an ordinary stoichiometry problem. The behavioral technologist works out the precise steps to be used, and later teaches these steps through a self-instruction program. One example of teaching a series of thought steps is provided by the little arithmetic illustration on page 99.

THE TEACHING SEQUENCES

Once the behavioral objectives of the course have been specified, and the behavioral analysis has been completed, step-by-step instructional sequences, known as frames, can be developed. After the frames are prepared, the program is tested with learners who are typical members of the target population for whom the program is intended. Invariably, some parts of the test program will be too easy, other parts too difficult, and many parts just confusing.

The responses and reactions of the testing group are used as a basis for revision. The revised version then is tested on another group of the typical learners. Again, the program is revised according to the test results. Usually three or four cycles of testing and revision are needed before a program is considered complete.

Professional programming groups generally demand that a finished program enable learners who have completed the program to score 90 percent, or better, on a final examination which covers the material taught in the program. Through repeated testing and revision, most of the rough spots in the program are eliminated. But it is not until the program meets the original specifications, and until most learners in the test groups are able to complete the program without ever being confused or getting stuck, that the program is released.

This is a simplified view of the production process. In practice, the process is quite intricate. Many specialized skills—the main determinants of the quality of the final product—are brought into play. The difference, therefore, between programs produced by experts and those produced by amateurs, particularly those who work alone and often do not have the advantage of consulting professional persons with many skills, is great indeed. These differences show up not only in the teaching effectiveness of the program, but also in the acceptability of the program to the learners. If a program is expertly produced, a target group of learners should be able to complete it with relatively little effort and pain, and attain a median score of 90 percent, or better, on a final examination.

Can a program be evaluated short of testing it on a selected group of learners? A practical, but not really satisfactory way to examine and evaluate a program is to take the program. If the program quickly becomes tedious, boring, confusing, or irritating, the chances are that something is wrong with it. Many programs require trivial or inconsequential responses from the learner, wasting his time and irritating him—the most common symptoms of inadequate behavioral analysis. If the program is confusing or ambiguous in spots, the program probably was not subjected to enough testing and revision. However, the evaluator may find the program too easy or trivial because it was intended for a target population with less knowledge; the evaluator simply knows too much. The only really valid way to evaluate a program is to try it out on members of the target population for whom the program was designed.

Programmed instruction may well have a significant impact upon nursing education during the next decade. Already, programmed texts for nurses are appearing with increasing frequency. Not all of these are good programs. But until nurses, as consumers of programs, are informed, discriminating, selective, and demanding, the characteristics and quality of the programs which are offered will continue to be uneven.

Like every other professional group today, nurses face an information explosion and must find ways to keep up with the accelerating pace of new developments. Against this background, programmed instruction holds considerable promise as an efficient, convenient, and accessible method of continuing education.