Programmed Instruction: 
A Fact of Educational Life

By Geary A. Rummel

Whatever happened to the teaching machine? Not much, really. But the “programmed” instructional materials used in the machine — that’s a different story. Programmed instruction materials and the general instructional technology underlying the materials have received wide acceptance and are being used in a variety of applications. For example: If you have flown on a commercial airline recently, chances are your reservation agent, ticket agent, stewardess, and cockpit crew had all received some of their training via programmed materials. Your long-distance operator learned a number of her new procedures from a programmed learning text. If you shop in a large department store, no doubt the sales clerks who waited on you learned how to operate the cash register and complete sales slips from a program. Your physician had the opportunity to learn more about “allergy and hypersensitivity” from a program distributed to him by Chas. Pfizer & Co. And your children may be learning new math, reading, or science from programmed materials.

The point is, programmed instruction is here; it is effective, and it is being used in a variety of instructional tasks.

WHAT IS PROGRAMMED INSTRUCTION?

Programmed Instruction is a process for the design and development of self-instructional materials. A program of instruction is simply a product of this process and is identified by the process, not by superficial characteristics of format of the product.

The process contains these steps:

1. task analysis
2. setting objectives
3. analysis and design of instructional content
4. developmental testing and revision
5. field testing
6. field administration

THE PROCESS

The process starts with the question of what you want the learner to be able to do, then analyzes the factors that would prevent the learner from reaching the objective, establishes an evaluation procedure for

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determining whether he has reached the objective, and ends with the development of instructional materials designed to obtain the desired behavior.

The general “test” or “system” analysis process of programming can be shown by this example: A company’s Director of Safety, wanting to reduce accidents in the plant, was considering the use of programmed instruction to educate supervisors about the need for safety. At this point, the programmer questioned the Director of Safety to determine specific objectives for the course. During the probing session, the programmer determined that:

1. The ultimate goal was to cut the number of lost-time accidents in half during the next year.
2. A major problem was the failure of supervisors to see safety hazards and to have them corrected.
3. Work orders or requisitions to have safety hazards reduced or removed received low priority because the plant manager always gave production work orders top priority.
4. The supervisor’s pay check was determined entirely by his production record and was not influenced in any way by the safety record of his department.

After this discussion, the programmer and the Director of Safety restated the hazard problem as:

1. Inability of supervisors to determine potentially hazardous conditions in the department.
2. Lack of reinforcement for suggesting changes since they all received low priority and often weren’t changed for months.
3. Lack of reinforcement for carrying out changes since the safety record was not a part of performance evaluation.

They agreed that point 1 was a training problem and would be handled by programmed instruction. Points 2 and 3 were systems or organizational problems.

The process of analysis is probably the most important single aspect of programmed instruction. First there is the statement of the problem. The training problem must be separated from other aspects of the problem, and specific behaviors must be isolated and considered for the course. During the analysis, certain “system” or organizational problems relevant to the desired behavior are identified. This makes it possible to teach the desired behavior and hopefully, to control or eradicate those variables in the system which influence this behavior.

After an analysis has been made, the more specific procedure of designing instructional material can be undertaken.

First, the objectives of the program are expressed in the form of a “Mastery Task” or final exam. Then instructional material is developed with the goal of teaching the student to accomplish the mastery task, thereby obtaining the instructional objectives. Early drafts of the materials are tried out (developmentally tested) on a small number of students to learn how to make them more effective. Following several tryouts and revisions, the materials are ready for field testing. After the materials have been shown to be effective in obtaining their instructional goal, the program is implemented.

THE PRODUCTS

Programs have a variety of formats and utilize different approaches based on the task to be taught. A program consists of units called “frames” or “items.” The learner analyzes or responds to these blocks of information or problems.

The following four frames are from a program on the basics of temperature-operated controls for new servicemen in a public utility.

(Note: the learner would see only one frame at a time. After responding to the question in the frame, he could check for the correct answer by turning the page.)

Because the copper is fused solidly to the steel, it cannot become longer than the steel without bending around it. The strip below has been heated. Which part is the steel, A or B?

Bi-metal Strip
Answer: B.

If the temperature changed from 60° to 80° would the bi-metal strip move toward A or B?

Copper Steel
Answer: B.

Continued on next page—
If you use the bi-metal strip as a pointer and combine it with a scale calibrated in degrees, you have a thermometer. Which is the copper, A or B?

![Thermometer Diagram]

Answer: A.

A thermostat is a temperature-activated switch. This switch is in the open position. What temperature change is needed to close the switch, increase or decrease?

![Thermostat Diagram]

Answer: decrease in temperature.

The following two frames are from a section on metaphors in a program on Poetry by Dr. James Cook: 1

One often hears statements like these: "The world is Joe's oyster," "Tom's a cool cat." Assuming that we know what the words mean, we recognize that a comparison is implicit in such statements. An implicit comparison is called a metaphor.

As you examine the examples A and B which follow, you can see that the metaphors imaginatively identify one object with another, and thus transfer to the first object one or more qualities of the second. The maker of the metaphor is suggesting that you consider what quality of 'Joe's oyster' can be ascribed to "the world." (Perhaps Joe lives in the world as easily as one swallows an oyster.)

Underline the metaphors you find in the following quotations:

A. I am a kind of farthing dip*
   Unfriendly to the nose and eyes;
   A blue-behindied ape, I skip
   Upon the trees of Paradise.

   Robert Louis Stevenson

   *Farthing dip is a cheap (one-fourth of a penny) candle which gives poor light and an obtrusive odor.

B. What is our life? A play of passion
   Our mirth the music of division
   Our mothers' wombs the tiring houses* be,
   Where we are dressed for this short comedy.

   Sir Walter Raleigh

   *A tiring house is an actor's dressing room.

C. Come live with me, and be my love,
   And we will some new pleasures prove
   Of golden sands, and crystal brooks,
   With silken lines, and silver hooks.

   John Donne

How many metaphors did you find in these examples? (Circle one) 1, 5, 3, 6.

You may have found 5 or 6 if you noticed that "Short Comedy" was compared to life.

By now you undoubtedly have inferred that a metaphor has two subjects:

(1) A principal subject like "world" or "Tom," to which the author applies the quality or qualities of the metaphoric word.

(2) A secondary subject, like "oyster" or "cat," which is the standard, literal meaning of the metaphoric word itself.

The principal subject is also called the tenor. The secondary subject is also called the vehicle.

Check the tenor and circle the vehicle:

(a) The world is Joe's oyster.
   (b) Tom is a cool cat.

(a) world (b) Tom (cat)

As you can see from these two examples, programs may vary considerably in their format, depending on their instructional objectives and subject matter. However, every program has a combination of certain characteristics which makes it unique as an educational device. Briefly, these features are:

1. Controlled Step Size. The frames contain problems and usually are sequenced in terms of increasing complexity, with later frames

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1 James Cook, Poetry: Method and Meaning, Educational Methods, Incorporated, Chicago.
requiring the manipulation of skills and concepts established in preceding frames. The increase in complexity between the frames is called “step size.” Through the testing of frames as they are written, the programmer arrives at the optimal conceptual step size between frames for the intended student population. The learner thus is confronted with challenges designed to be neither so complex as to be perplexing nor so simple as to be boring.

2. Immediate Feedback. Generally, the learner sees the relationship in the frame and knows he has solved the problem correctly. Since the correct answer or confirmation is always presented immediately following the frame, the learner always knows where he stands in the learning situation.

3. Active Response. This means more than writing a word or two in a blank, which is often the meaning construed from looking at programs. Rather, it is the process basic to learning any concept or manipulating any facts. It is the process of analyzing examples of a concept, discriminating among the points of difference, and forming concepts. In programming, the student responds actively to each frame, sees the relationship, and makes the discrimination himself.

4. Self-Pacing. Because of this immediate feedback and problem-solving feature of programs, they are self-instructional devices which are self-pacing. The speed with which a trainee goes through the program is a function of his ability to discriminate and solve problems. Regardless of the pace, every learner will be able to perform the objective at the conclusion of the program.

The values of these features to the learner and organization are shown in Figure 1.

A DEFINITION

Now it is possible to give a meaningful definition of programmed instruction as: “Empirically Developed Validated Self-Instruction.” This is inclusive and useful definition, since: Empirically developed is a definition of the process of developing programmed materials. As was mentioned earlier, the preferred process includes these steps:

1. Task analysis
2. Objectives specification
3. Analysis and design of instructional content
4. Developmental testing and revision
5. Field testing
6. Field administration

Validated self-instruction is a definition of the function of programmed materials. That is, the function of programmed materials is to effectively (“validated”) instruct individual learners. As we have already noted, the format or observed characteristics of programmed materials vary considerably as a function of the tasks or subject matter being taught. Thus, programmed materials could be defined in terms of typical characteristics such as those mentioned earlier.

The definition of programmed learning has undergone a natural evolution, beginning with early characteristic-centered definitions. Since early examples of programmed materials dealt with limited subject matters and the characteristics varied very little, definition of this aspect was useful. However, as the amount of programmed materials grew and a variety of tasks were taught to differing student populations, varying formats appeared. Since characteristic alone no longer adequately described programmed materials, a functional definition such as “validated self-instruction” emerged. Recently, it has been felt that the process by which programmed materials are developed is the key to their ultimate effectiveness, and subsequently is critical to an adequate definition of programmed learning. Thus, the addition of “empirically developed.”

USES OF PROGRAMMED INSTRUCTION

As was indicated earlier, programmed instruction materials have been used in a variety of applications. But an important point is that programmed instructional materials don’t have to be limited to paper and pencil presentation. Indeed there are a number of examples where entire laboratories have been programmed (Michigan Bell Telephone Basic Electronics Course) and paper-and-pencil programs have been combined with other media and integrated with “hands-on” practice sessions (eg. Bell System First Aid and Personal Safety Course and Trans World Airline Crew Training for the DC-9 aircraft). Integrated systems based on the same principles and processes of programmed instruction such as these are frequently referred to as complete instructional systems. Very often, however, programs are predominantly “paper and pencil” because of the relatively low expense and the fact that they frequently do the job as efficiently as more elaborate media arrangements.

SOURCES OF PROGRAMS

Programmed materials can be obtained in three ways: by purchasing published “off-the-shelf” programs; by having a consulting firm develop a program for you; or by having your own staff develop a

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program. Each method is advisable under certain conditions.

1. Off-The-Shelf Programs. Some firms have published programs for general consumer purchase, most of which have been aimed at the educational market. Most programs on industrial topics that have objectives precise enough to be effective are too specific for widespread application. Published programs give you the opportunity to review a program and evaluate its effectiveness in your organization with a minimal investment. Their costs vary from about $18.00 to $30.00.

2. Contract Programs. When you have a program written for you, you are generally relying on expert programmers and should expect a good product for your money. You can, moreover, observe the entire process and final effectiveness with more objectivity than if it were your own project. A possible disadvantage of having a program developed on a custom-made basis is the cost. The price will reflect the premium you must pay in hiring an expert who must first become familiar with your organization and who will then work for you on an ad hoc basis.

3. Developing a Program Within Your Organization. There are certain obvious disadvantages of developing your own program. Since the responsibility lies wholly within the organization, time and manpower must be taken from other jobs. Moreover, the program might not be as effective as those professionally developed. However, if properly trained, the staff programmer will be as competent as a great many of the programmers in professional firms. The advantages of a do-it-yourself program development are that the program will be overseen by one person from its inception through its testing, revision, and perfection, and that tailor-made precision can be combined with relatively moderate costs.

More information on programs and programmed instruction can be obtained from:
The National Society of Programmed Instruction
Trinity University
715 Stadium Drive
San Antonio, Texas 78212

The Center for Programmed Learning for Business
506 East Liberty
Ann Arbor, Michigan 48108

NOTE OF CAUTION

Every article on programmed instruction should (and does) end on a note of caution. It is interesting how the content of these cautionary notes has changed over the years. In the late 50's there were no notes of caution. It seemed possible that programmed instruction would save the world. In the early 60's we had had enough experience with the inappropriate "programming" of enough topics (and were stunned with the enthusiasm with which people received this hoped for instructional savior) to cause us to warn that programmed instruction was not a "panacea".

"Remember, programmed learning is only a technique which facilitates learning. If applied to a badly organized training program by a poor programmer, it will fail miserably. In short, programmed learning is not a miracle salve which can be slapped over old training sores with the hope of a quick cure."

Not much later, there was concern over the apparent over-emphasis on the need for hardware (the teaching machine). This prompted us to warn:

"As a result of articles in the popular press, 'teaching machines' have for many people become synonymous with programmed learning. A great many boxes, audiovisual devices, and mechanical gadgets have been labeled 'teaching machines' by manufacturers and educators. The critical part is the program in the machine. In fact, the vast majority of programs published today are in a bound volume or book presentation. Teaching machines should be evaluated just as you would any machine your organization would consider buying. As if it will fill a need and if it is worth the money to fill the need. To the extent that it is necessary to control the presentation (tape recorder for language program), simulate the task (pilot training), or simulate the conditions of the task (through a microscope for lab technicians), teaching machines would seem worth considering. But in most cases they are not necessary.

A continuing concern regarding the use of programmed instruction is that the management or administration have realistic expectations of its value and of the commitment required on their part.

2 Geary A. Rummel: An address before the annual convention of National Retail Merchants Association, New York City, January 8, 1963.


Continued on next page—
“.......... programming has been called both a revolution and another training gimmick. It can be either, depending on how it is used by the individual organization. To obtain the best results from programmed learning, management must be aware that the results derived from programming will be directly proportional to the care and effort put into it.”

All these notes of caution are still very appropriate. One final note has to do with the varying quality of materials labeled as programmed instruction. There is nothing to prevent someone from calling a set of instructional materials “programmed instruction”. It is not too difficult to turn out a product which has the observable characteristics of programmed instructional materials. But, it is the process of development which determines whether an instructional product is a program. If instruction is programmed, it will have been validated. If it has been validated, there will be data. Ask for it. If someone approaches you about using a program, ask “what evidence do you have that it will do the job?” If there is no evidence, you may be on dangerous ground. If there is evidence that this program can deliver the performance you desire, then you are on your way to the successful use of one of the greatest innovations in modern education.

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FIGURE 1
FEATURES AND BENEFITS OF PROGRAMMED INSTRUCTION

<table>
<thead>
<tr>
<th>FEATURES OF PROGRAMMED LEARNING</th>
<th>BENEFITS TO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>THE LEARNER</td>
</tr>
<tr>
<td>1. Empirically Developed</td>
<td>1. learns only relevant material.</td>
</tr>
<tr>
<td>2. Validated</td>
<td>2. receives instruction which will be effective and useful.</td>
</tr>
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<td></td>
<td></td>
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</tbody>
</table>
| 4. Pre-specified goals          | 4. Knows where he is going and how he is progressing. | 4. a) uniform training  
|                                 |             | b) economic evaluation possible. |
| 5. Active responding and immediate feedback. | 5. Guided to analyzing relevant factor and making a decision. Can evaluate his own performance. | 5. Can observe student performing on tasks simulating the job. |
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