Programmed Instruction - Engineered Instruction Re-Visited

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Abstract
Programmed Instruction (PI) was one of a number of technologies derived from Behaviorism during the 1960's. This paper outlines the elements of PI and summarizes its effective use at West Virginia University.

Behaviorism as a Technology

As teachers, our job is to deliver skills and knowledge to our customers. No psychological concept provides more powerful tools to accomplish this task than Behaviorism, a product of the Twentieth Century.

It is the basis of two powerful and related methods, Programmed Instruction (PI) and Behavior Modification (Behavior Mod). At heart, both methods rely on four simple principals:
1. Know what you want to accomplish.
2. Place your subjects in an appropriate environment.
3. Keep your eye on your subjects' behavior.
4. Reward appropriate behavior.

In reality, there was little new in the way of principles introduced. The contribution was in their rigorous and focused application. It can be said that they represent the application of the engineering design process to education and training.

As a general philosophy, strict Behaviorism has been subjected to severe criticism because some of its leading proponents insisted that all learning is controlled strictly by conditioning. This has serious religious and/or philosophical implications in arguments about concepts such as "thinking" and "free will." This paper is concerned with it only as a foundation for a technology. It is presented here as a set of heuristics for the design of instruction.

Behavior Modification, also called operant conditioning, is still popular. It is particularly widely used in animal training. It is easily visualized as a method of correcting children, but it equally applicable to adults. One of the author's teachers, Julie Skinner Vargas, even required each of her students to conduct an experiment in using it to change their own behavior.

Fred Keller's invention, PSI, the "Proctorial System of Instruction" or "Personalized System of Instruction" was based on similar principles. It was, however, constructed as a practical solution

for use in “everyday” circumstances rather than as an ideal design for maximum effectiveness. PI is very labor intensive during development and Behavior Mod is labor intensive in application.

Basic Ideas in Designing PI

On a gross scale, a PI text, a classic engineering review book, and an elementary school “workbook” may appear similar in construct. All provide questions and answers. The difference is that PI focuses on the control of behavior while the other two focus primarily on content. Much was written about the design of PI. Literature, some good, [1] some poor, will be found in the education sections of any university library. The following sections summarize a few important points.

Behavioral Objectives

The term “behavioral objectives” is generally similar in meaning to the currently popular term “educational outcomes.” Both describe what a student is expected to do after completing an instructional sequence. In a sense there is a difference in that “outcomes” generally refer to the “public” list which outlines the product while behavioral objectives refer to the detailed specifications which are used in the design process.

For an engineering course, the primary objectives may largely be a list of types of problems which you will expect average student to solve correctly when they have completed the unit. Sub-objectives should include vocabulary which the student must use correctly and identifiable steps which you would expect to see in a problem solution. Objectives can be written for design, experimentation, etc., but this is more difficult than for “engineering science” fundamentals.

Just as the rigorous design of a machine will start with a precise specification of expected test performance, a rigorous educational design will start with specifications for terminal behavior, and generally include specification of a pool of terminal test items or a criterion test.

Frames

PI is constructed in a series of “frames.” Each frame is a single setting and response, typically a single question. The term derives from B.F. Skinner's Teaching Machines which had rectangular holes in which material was displayed and answers were written. A program is constructed of several types of frames, which may be focused on introduction, vocabulary, memorization, critical steps, solution of complete problems, and a closure.

Linear v. Branching Design

A Linear Program has a single path, although it should allow escapes. A Branching Program includes a variety of paths selected either by the user or, based on answers to questions, by the author. Branching looks attractive, but in fact good students want to explore all paths, and poor ones are typically routed through them all by design. Branching is not too useful in engineering science where all students are rather naive and all material should be covered.

Correct Responses

Effective learning occurs only when student behavior is shaped through positive reinforcement. PI tries teach a correct way from the first. While sometimes it may be desirable to show "common errors," if students are lead to perform incorrectly, they will frequently do so afterwards.

To achieve high levels of correct response, it is generally necessary to use a rather large number of frames of increasing complexity and declining strength of prompting. The PI texts written at West Virginia University (WVU) typically took about 1500 frames to achieve satisfactory results with a sophomore engineering course.

Active Response

A student learns only what a program leads him to do. Data from the testing of programs have supported this theoretical statement many times. Of course for professional level education the responses must include wide variety of behaviors running from recall of facts through analysis, decision making, and evaluation of results. Everything to be learned must be required in the response to at least one item, and typically several.

Constructed Responses

A "constructed response item" is a frame which asks a student to provide something like a word, a phrase, a drawing, or a numerical answer. One of the traditional principals of PI is that a "constructed response" is usually preferable to a multiple choice item. This is because students are to learn to draw, calculate, and report, not simply press buttons.

Immediate Reinforcement

With PI, students are given immediate feedback on their responses. Ideally this results in giving "reinforcement" through a confirmation that their work is correct.

Developmental Testing

During development, a program is given to a series of test subjects (students). The author will observe and record student behavior as each subject completes the unit. If a subject misses a question, the author will attempt to ascertain why, and to correct the program rather than the subject. A program must be revised until students master the material.

PI Versus Instructional Programs

It is easy to confuse Programmed Instruction with "instructional programming" for computers, or Computer Based Instruction (CBI). Historically there was much communality. B. F. Skinner coined the term Programmed Instruction in conjunction with his pre-computer "Teaching

Machines." Had inexpensive electronic computers been available in 1960, education might be greatly different today. A few programs applied PI to CBI. As a practical matter, books proved to be the only convenient way of delivering behaviorally designed instruction on a mass scale, and most people associate PI with books.

Current computer platforms are an excellent potential base for the development and administration of PI. Unfortunately little current computer based instruction applies its effective techniques. [2] Most "multi-media instruction" merely asks students to <click here> to continue.

One of the principal difficulties in transferring the techniques of PI to CBI lies in the judging of answers to constructed response frames. Because answer judging is difficult, it has become increasingly common to avoid questions which require even word answers. Evaluating becomes even more difficult in engineering where the programmer should evaluate a student's equations or drawings as part of an instructional sequence.

PI at West Virginia University

Under the leadership of Helen Plants, West Virginia University was probably the world leader in applying programmed instruction to engineering. For almost two decades we offered our students the opportunity to take undergraduate courses in Statics, Dynamics, and Mechanics of Materials with either PI or traditional methods. Several thousand students passed through both "programmed" classes, and parallel "lecture" offerings.

Each semester a common departmental examination was given to all students in each of the courses. Occasionally lecture classes would average as high as programmed sections, and, of course, individual students performed well with each system of instruction. Overall, however, performance of students in programmed classes was statistically better. [3] [4]

Selected Bibliography

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