Programmed Instruction, Programmed Branching, and Learning Outcomes

Robert S. Owen
Texas A&M University-Texarkana, USA

Bosede Aworuwa
Texas A&M University-Texarkana, USA

INTRODUCTION

This chapter discusses the principles of two qualitatively different and somewhat competing instructional designs from the 1950s and '60s, *linear programmed instruction* and *programmed branching*. Our hope is that an understanding of these ideas could have a positive influence on current and future instructional designers who might adapt these techniques to new technologies and want to use these techniques effectively. Although these older ideas do still see occasional study and debate (e.g., Dihoff, Brosvic & Epstein, 2003, 2004), many current instructional designers are probably unaware of the learning principles associated with these (cf., Fernald & Jordan, 1991; Kritch & Bostow, 1998).

BACKGROUND

An important difference between these instructional designs is associated with the use of feedback to the learner. Although we could provide a student with a score after completing an online multiple-choice quiz, applications that provide more *immediate feedback* about correctness upon completion of each individual question might be better. Alternatively, we could provide *adaptive feedback* in which the application provides elaboration based upon qualities of a particular answer choice.

Below is a discussion of two qualitatively different instructional designs, one providing immediate feedback regarding the correctness of a student's answer, the other providing adaptive feedback based on the qualities of the student's answer. Suitability of one design or the other is a function of the type of learner and of the learning outcomes that are desired.

MAIN THRUST OF THE ARTICLE

Although the idea of non-human feedback would seem to imply a mechanical or electronic device, other methods could be used. Epstein and his colleagues, for example, have used a multiple-choice form with an opaque, waxy coating that covers the answer spaces in a series of studies (e.g., Epstein, Brosvic, Costner, Dihoff & Lazarus, 2003); when the learner scratches the opaque coating to select an answer choice, the presence of a star (or not) immediately reveals the correctness of an answer. Examples of the designs discussed below are based on paper books, but they are easily adaptable to technologies that use hyperlinks, drop-down menus, form buttons, and such.

Linear Programmed Instruction

The programmed psychology textbook of Holland and Skinner (1961) asked the student a question on one page (the quote below starts on page 2) and then asked the student to turn the page to find the answer and a new question:

"A doctor taps your knee (patellar tendon)
with a rubber hammer to test your __________."

The student thinks (or writes) the answer and turns the page to find the correct answer ("reflexes") and is then asked another question.

Questions or statements are arranged in sequentially ordered *frames* such as the single frame above. A frame is completed when the student provides a response to a stimulus and receives feedback. Skinner contended that this method caused learning through *operant conditioning*, provided through positive *reinforcement* for stimuli that are designed to elicit a correct answer (c.f., Cook, 1961; Skinner, 1954, 1958).

Skinner (and others who use his methods) referred to his method as *programmed instruction*, which incorporates at least the following principles (cf., Fernald & Jordan, 1991; Hedlund, 1967; Holland & Skinner, 1958, 1961; Whitlock, 1967):

- Clear learning objectives.
- Small steps; frames of information repeat the cycle of stimulus-response-reinforcement.
- Logical ordered sequence of frames.
- Active responding by a student who works at his/her own pace.
- Immediate feedback to the response in each frame with positive reinforcement for correct answers.

A technique in programmed instruction is to help the student a great deal at first, and then gradually reduce the cues in latter frames; this is called *fading* (Fernald & Jordan, 1991; Reiff, 1980). If correct responding suggests that a student is learning at a quick rate, *gating* can be used to skip over frames that repeat prior information (Vargus & Vargus, 1991). The programmer is expected to use information about student performance to make revisions; if the student is not succeeding, then it is due to a fault of the program, not to an inability of the student (Holland & Skinner, 1961; Vargus & Vargus, 1991).

Programmed Branching

Crowder (e.g., 1959, 1963) and others (e.g., Pressey, 1963) were critical of Skinner's approach, arguing that students not only learn from knowing a correct answer, but also learn by making mistakes. Crowder distinguished between his *automatic tutoring device* and the Skinner-type *teaching machine*, proposing that the automatic tutoring device is more flexible in allowing the student to receive an explanation when an error is made. Crowder (1959, pp. 110-111) provides an example of how this approach could be used in a programmed textbook:

> "In the multiplication of 3 x 4 = 12, the number 12 is called the *product* and the numbers 3 and 4 are called the
>
> | | |
> |---|---|
> | Page 15 | quotients. |
> | Page 29 | factors. |
> | Page 43 | powers." |

In this *programmed branching* method of Crowder, the student is taken to one of several possible discussions depending on the qualities of the answer.

While Skinner's design would be expected to work only when stimuli elicit correct answers, Crowder's design allows for mistakes and must be designed to anticipate particular mistakes. Crowder believed that this method caused learning through *cognitive reasoning*. Whatever answer is chosen by the student, the programmed textbook (or machine) makes a *branch* to a discussion associated with issues relevant to the answer that was chosen. This is followed by a return to the same question if the student had made an incorrect choice, or a jump to new a *frame* containing the next question if the student had made a correct choice.

Learning Outcomes

Many issues have been raised about programmed instruction methods. Reiff (1980) discusses several criticisms:

- It does not take into consideration the sequence of development and readiness to learn (e.g., children of different ages or children vs. adults).
- It develops rote learning skills rather than critical thinking skills.
- Students can in some implementations cheat.
- The encouragement to respond quickly could develop bad reading habits.

Crowder's *programmed branching* design, which has received far less attention and study than Skinner's ideas, would seem to answer at least some of these criticisms. Crowder's design provides an explanation to both correct and incorrect answers, so the learner is not rewarded for cheating or working too quickly. Since the explanation is tied to the learner's thinking at the time a choice was made, Crowder's design would appear to be better to develop critical thinking skills, but might not be so good at developing rote learning skills. Crowder's design would appear to be better suited to students who have a greater readiness to learn, while perhaps not so well suited to a student who is at an earlier stage of learning a subject.

The above discussion suggests that each of these designs is useful, but that each is useful in different kinds of situations and that the *learning outcomes* of each approach might be different. Skinner's teaching machine, for example, might be more useful in situations where students are learning lists and definitions. The automatic tutoring device, on the other hand, might be more useful when the student is already at a higher level of understanding, whereby s/he can now use reasoning to derive an answer, or in situations where the student understands that there are degrees of right and wrong without concrete answers. The Skinner-type teaching machine might be better suited to "lower-order" levels of learning, while the Crowder-type automatic tutoring device might be better suited to "higher-order" levels of learning.

Although many ideas have been proposed with regard to a hierarchical perspective on "lower" and "higher" levels of learning, the most well-known, "Bloom's Taxonomy" (A Committee of College and University Examiners, 1956), originated in about the same timeframe as the