Chapter 4:

From Behaviorism to Mastery learning

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Examples of exam questions

① In which ways does this learning technology correspond to a behaviorist approach?

② For which kind of learners is it relevant to choose inverted progressivity?
Yvan Pavlov, 1849-1936

Classical **Conditioning**
Edward L. Thorndike (1874 – 1949) **The Law of Effect**: any behavior that is followed by pleasant consequences is likely to be repeated, and any behavior followed by unpleasant consequences is likely to be stopped.
John Watson (1878-1958) Behaviourism

"Give me a dozen healthy infants, well-formed, and my own specified world to bring them up in and I'll guarantee to take any one at random and train him to become any type of specialist I might select -- doctor, lawyer, artist, merchant-chief and, yes, even beggar-man and thief, regardless of his talents, penchants, tendencies, abilities, vocations, and race of his ancestors."

--John Watson, Behaviorism, 1930

The Little Albert Experiment
Burrhus Frederic Skinner (1904-1990), Operant Conditioning

**SKINNER OPERANT CONDITIONING**

- **BEHAVIOR**
  - UNDESIRED NEGATIVE
    - GIVE PAIN
    - REMOVE PLEASURE
  - DESIRED POSITIVE
    - GIVE PLEASURE
    - REMOVE PAIN
    - MAINTAIN POSITIVE
      - FADE Reinforcers
        - 21 DAYS

"The closer you implement a Reinforcer to a Behavior, the greater the chance of changing behavior"
Key ideas in behaviorism

① Psychology is becoming more scientific
② The brain is a black box; the focus is on behaviors
③ Learning is « engineered »
④ Association results from immediate feedback
⑤ The learner is permanently active
⑥ Small steps increase the probability of positive feedback ➔ Programmed instruction
B. F. Skinner

FIG. II. Student at work in the self-instruction room. Material appears in the left-hand window. The student writes his response on a strip of paper exposed at the right.
B.F. Skinner's Teaching Machine

Instructional "disks" are placed inside the machine along with a strip or roll of paper. When the machine is closed, the student reads a question through a window and writes their response on the strip of paper. The student then compares their answer with the answer on the disk and presses the lever one way if their answer is correct or the other way if incorrect (the machine keeps score and advances).

Skinner proposed the machine improves learning by "taking into account the rate of learning for each individual learner." With this, Skinner formalizes "self-paced instruction" as part of programmed instruction.
Table 2. PART OF A PROGRAM IN HIGH-SCHOOL PHYSICS

The machine presents one item at a time. The student completes the item and then uncovers the corresponding word or phrase shown at the right.

<table>
<thead>
<tr>
<th>SENTENCE TO BE COMPLETED</th>
<th>WORD TO BE SUPPLIED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The important parts of a flashlight are the battery and the bulb. When we “turn on” a flashlight, we close a switch which connects the battery with the ______.</td>
<td>bulb</td>
</tr>
<tr>
<td>2. When we turn on a flashlight, an electric current flows through the fine wire in the ______ and causes it to grow hot.</td>
<td>bulb</td>
</tr>
<tr>
<td>3. When the hot wire glows brightly, we say that it gives off or sends out heat and ______.</td>
<td>light</td>
</tr>
<tr>
<td>4. The fine wire in the bulb is called a filament. The bulb “lights up” when the filament is heated by the passage of an(um) ______ current.</td>
<td>electric</td>
</tr>
<tr>
<td>5. When a weak battery produces little current, the fine wire, or ______, does not get very hot.</td>
<td>filament</td>
</tr>
<tr>
<td>6. A filament which is less hot sends out or gives off ______ light.</td>
<td>less</td>
</tr>
<tr>
<td>7. “Emit” means “send out.” The amount of light sent out, or “emitted,” by a filament depends on how ______ the filament is.</td>
<td>hot</td>
</tr>
</tbody>
</table>

1. Information
2. Question
3. Feedback

Frame-Based Models

- **Decomposition**: Segmenting complex contents into a sequence of learning steps that contains an elementary piece of information.

- Keep the student **active** all the time, ask the student to process any new piece of information.

- Provide **immediate feedback**

- Let the student move on at his or her own speed

Based on behaviourism-inspired “programmed learning instruction”
Branched Instruction

AutoTutor, Crowder
1. Information
2. Question
3. Feedback

Frame-Based Models

- Decomposition: Segmenting complex contents into a sequence of learning steps that contain an elementary piece of information
- Keep the student active all the time, ask the student to process any new piece of information
- Provide immediate feedback
- Let the student move on at his or her own speed.

- Individualisation: adapt instruction to the student needs

Based on behaviourism-inspired “programmed learning instruction”
Mastery Learning

- Larger granularity: modules > frames
- Permanent control of effectiveness
"about 90% of the tutored students ... attained the level of summative achievement reached by only the highest 20% of the control class.

Modular Instruction

Pre-requisite test: Does the learner have the pre-requisite to start the course?

Pre-test: Should the learner skip some modules?

Intermediate-test: Did the learner reach the objectives of this module?

Post-test: Did the learner reach the objectives of this course?

Adaptive Testing

Downhill strategy: go down until he succeeds

Uphill strategy: go up until he fails

Discriminant strategy: increase/decrease difficulty based on success – cut the space in 2
Personalized Instruction
Individual instruction
Adaptive instruction

Optimization in learning environments
Aptitude x Treatment Interaction (ATI)

Aptitude A  Aptitude B

Achievement

Treatment A
Treatment B

Aptitude-Treatment Interactions:

The effect of a pedagogical method varies for different learners' profiles.

Mastery Learning Efficiency
Lisp Programming Tutor

• **Cognitive Mastery vs. Fixed Curriculum:**
  – 40% more problems
  – 14% more time
  – 25% greater accuracy on post-test
  – 570% increase in mastery as
  – Effect size: $d=0.65$


By courtesy of Vincent Aleven, CMU
Evaluations of Intelligent Tutoring Systems

• Study with 17,000 students showed that Cognitive Tutor Algebra (a curriculum + ITS) doubled students’ algebra learning (Pane et al., 2013)

• Meta-review indicates that ITSs are “nearly as effective as human tutoring” (VanLehn, 2011)

• Four meta-analyses show ITSs are often more effective than other forms of instruction (Kulik & Fletcher, 2015; Ma, Adesope, Nesbit, & Liu, 2014; Steenbergen-Hu & Cooper, 2013; 2014)
Adapting to what?

- Level of performance/knowledge
- Learning style:
  - Surface vs deep
  - Visual, auditory vs kinesthetic
  - Field-dependent,....
Instructional design: from tradition to engineering

http://www.historicbridges.org/
(1) Start from the goals:
   • What should the learner be able to do at the end of the course?
   • How will you know they are able? (write the exam before the course)
   • Which kind of skill is that?

(2) Decompose contents:
   • THINK$^2$ : think what students need to think to acquire the concept

(3) Chose the activities, sequence them as a scenario ➔ graph
Instructional design

(1) Start from the goals:

• Who are the learners (target audience) ?
• What should they be able to do at the end of the course ?
• How will you know they are able ? (write the exam before the course)
• Which kind of skill is that ? (taxonomy of cognitive activities)
Bloom’s Taxonomy

Creating:
Can the student create new product or point of view?
Assemble, Construct, Create, Design, Develop, Formulate, Write

Evaluating:
Can the student justify a stand or decision?
Appraise, Argue, Defend, Judge, Select, Support, Value, Evaluate

Analyzing:
Can the student distinguish between the different parts?
Appraise, Compare, Contrast, Criticize, Differentiate, Discriminate, Distinguish, Examine, Experiment, Question, Test.

Applying:
Can the student use the information in a new way?
Choose, Demonstrate, Dramatize, Employ, Illustrate, Interpret, Operate, Schedule, Sketch, Solve, Use, Write

Understanding:
Can the student explain ideas or concepts?
Classify, Describe, Discuss, Explain, Identify, Locate, Recognize, Report, Select, Translate,

Remembering:
Can the student recall or remember the information?
Define, Duplicate, List, Memorize, recall, Repeat, Reproduce, State

http://wglink.pbworks.com/w/page/38080839/Bloom's%20Triangles
Why using a taxonomy?

• To avoid natural bias towards low-level activities (easier to measure)
• As a prism to invent a variety of objectives
Instructional design

(1) Start from the goals:
   • Who are the learners (target audience)?
   • What should they be able to do at the end of the course?
   • How will you know they are able? (write the exam before the course)
   • Which kind of skill is that? (taxonomy of cognitive activities)

(2) Decompose contents:
   • THINK²: think what students need to think to acquire the concept
Find summit opposite to \(ab\)

Measure \([c - ab]\)

Select a base

Measure the base

Draw line by \(c\) orthogonal to \(ab\)

Multiply

Divide by 2

Triangle \(abc\)

Content Analysis
(mathetic analysis)
A *triangle* is a polygon with 3 vertices.

A *polygon* is a plane figure bounded by a finite chain of straight line segments.

A *plane* is a flat two-dimensional surface.

A *line segment* is a part of a line that is bounded by two distinct end points.

The vertex of an angle is the point where two line segments join or meet.

A *right angle* has an amplitude of 90 degrees.

An *hypotenuse* is the side of a right triangle opposed to the right angle.

A *right triangle* is a triangle in which one angle is a right angle.

In a right triangle, the square of the hypotenuse is the sum of the squares of the two other sides.
Instructional design

(1) Start from the goals:

- Who are the learners (target audience) ?
- What should they be able to do at the end of the course ?
- How will you know they are able ? (write the exam before the course)
- Which kind of skill is that ? (taxonomy of cognitive activities)

(2) Decompose contents:

- THINK² : think what students need to think to acquire the concept
- What are the pre-requisites ? Are they reasonable for this audience ?

(3) Chose the activities, sequence them as a scenario ➔ graph
Instructional design

(1) Start from the goals:
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Instructional design

(3) Chose the activities, sequence them as a scenario ➔ graph (Assignment 2)

<table>
<thead>
<tr>
<th>Preparation</th>
<th>Set</th>
<th>Translation</th>
<th>Generalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P) Prerequisite</td>
<td>(S+) Aggregation</td>
<td>(T) Proceduralization</td>
<td>(G+) Induction</td>
</tr>
<tr>
<td>(P) ZPD</td>
<td>(S+) Expansion</td>
<td>(T) Elicitation</td>
<td>(G+) Deduction</td>
</tr>
<tr>
<td>(P) Adv. organizer</td>
<td>(S–) Decomposition</td>
<td>(T) Alternate</td>
<td>(G+) Extraction</td>
</tr>
<tr>
<td>(P) Motivation</td>
<td>(S–) Selection</td>
<td>(T) Reframe</td>
<td>(G+) Synthesis</td>
</tr>
<tr>
<td>(P) Anticipation</td>
<td>(S=) Juxtaposition</td>
<td>(T) Reverse</td>
<td>(G=) Analogy</td>
</tr>
<tr>
<td>(P) Logistics</td>
<td>(S=) Contrast</td>
<td>(T) Repair</td>
<td>(G=) Transfer</td>
</tr>
<tr>
<td>(P) Data collection</td>
<td>(S=) Identity</td>
<td>(T) Teach</td>
<td>(G–) Restriction</td>
</tr>
</tbody>
</table>