

CS-411 : Digital Education & Learning Analytics

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 ?



http://www.nobelprize.org/nobel_prizes/me dicine/la ureates/1904/pavl ov-bio.html

Yvan Pavlov, 1849-1936

Classical **Conditioning**



The unconditioned stimulus is repeatedly presented just after the neutral stimulus. The unconditioned stimulus continues to produce an unconditioned response. The neutral stimulus alone now produces a conditioned response (CR), thereby becoming a conditioned stimulus (CS).

(salivation)

(salivation)



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.



Adapted from Domjan, 1993 (modified from Thorndike, 1898 [left] and Imada & Imada, 1983 [right]) http://www.simplypsychology.org/edward-thorndike.html

Edward L. Thorndike, The Law of Effect, The American Journal of Psychology Vol. 39, No. 1/4 (Dec., 1927), pp. 212-222: http://www.jstor.org/stable/1415413



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, merchantchief 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 Conditonning



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 lefthand window. The student writes his response on a strip of paper exposed at the right.

B.F. Skinner's Teaching Machine



(c) Julie S. Vargas

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.

Linear 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.

	SENTENCE TO BE COMPLETED	WORD TO BE SUPPLIED
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	bulb
2.	When we turn on a flashlight, an electric current flows through the fine wire in the and causes it to grow hot.	bulb
3.	When the hot wire glows brightly, we say that it gives off or sends out heat and	light
4.	The fine wire in the bulb is called a filament. The bulb "lights up" when the filament is heated by the passage of a(n) current.	electric
5.	When a weak battery produces little current, the fine wire, or, does not get very hot.	filament
6.	A filament which is less hot sends out or gives off light.	less
7.	"Emit" means "send out." The amount of light sent out, or "emitted," by a filament depends on how the filament is.	hot

http://66.31.107.147/~heines/academic/papers/2002elearn/images/Lumsdaine_Glaser/

- 1. Information
- 2. Question
- 3. Feeback
- 1. Information
- 2. Question
- 3. Feeback
- 1. Information
- 2. Question
- 3. Feeback
- 1. Information
- 2. Question
- 3. Feeback
- 1. Information
- 2 Augetian

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



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• Individualisation: adapt instruction to the student needs

Based on behaviourism-inspired "programmed learning instruction"

2 Augetian



FIGURE 1. Achievement distribution for students under conventional, mastery learning, and tutorial instruction.



<u>Bloom</u>, B. (1984). "The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring", Educational Researcher, 13:6(4-16).



Modular Instruction

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

Pre-test: Should the learner skip some modules ?

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

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

Adaptive Testing



Daphne Koller

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 Science Reporters and Editors on Twitter

Like the science desk on Facebook.

American work force was in agriculture, and there were frequent food shortages. Today, agriculture accounts for less than 2 percent of the work force, and there are food

surpluses. The key to this transition was the use of technology-from crop rotation strategies to GPS-guided farm machinery which greatly increased productivity. By contrast, our approach to education has remained largely unchanged since the Renaissance: From middle school through college, most teaching is done by an instructor lecturing to a room full of students, only some of them paying attention.

Personalized Instruction Individual instruction Adaptive instruction

Optimization in learning environments

. . .





Cronbach, L. & Snow, R. (1977). Aptitudes and Instructional Methods: A Handbook for Research on Interactions. New York: Irvington

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

Corbett, A. (2001). Cognitive computer tutors: Solving the two-sigma problem. In M. Bauer, P. J. Gmytrasiewicz, & J. Vassileva (Eds.), *Proceedings of the 8th International Conference on User Modeling, UM 2001* (pp. 137-147). Springer Berlin Heidelberg. doi:10.1007/3-540-44566-8_14

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:

• THINK² : think what students need to think to acquire the concept

(3) Chose the activities, sequence them as a scenario \rightarrow graph

(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*)



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



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Content Analysis

(mathetic analysis)

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



Content Analysis

(semantic analysis)

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- 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*)
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(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 ?

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

Preparation	Set	Translation	Generalizatio
			n
(P) Prerequisite	(S+) Aggregation	(T) Proceduralization	(G+) Induction
(P) ZPD	(S+) Expansion	(T) Elicitation	(G+) Deduction
(P) Adv. organizer	(S–) Decomposition	(T) Alternate	(G+) Extraction
(P) Motivation	(S–) Selection	(T) Reframe	(G+) Synthesis
(P) Anticipation	(S=) Juxtaposition	(T) Reverse	(G=) Analogy
(P) Logistics	(S=) Contrast	(T) Repair	(G=) Transfer
(P) Data collection	(S=) Identity	(T) Teach	(G–) Restriction